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THE JOLIET WATER POWER CONTROVERSY, involving the right of a private person to condemn the water rights of the Chicago Sanitary District, and vitally affecting the proposed development of water power from the discharge of the Chicago drainage canal, has been decided in favor of the district. The condemnation suit has been dismissed by the lower court, but the right to appeal to the supreme court has been granted. The plaintiff, Mr. Robert Gaylord, sought to condemn a strip of land along the drainage canal, but the court held that the proposed grist mill and navigation facilities were not private uses, and that public property could not be condemned for private uses. Mr. Gaylord has secured rights, independent of the drainage canal property, which, it is claimed, are sufficient for the development of 6,000 HP.

A SOUTHERN WATER POWER DEVELOPMENT of some importance is about to be carried out on the Chattahoochee River, near Atlanta, Ga. A fall at Bull Sluice Shoals, about 15 miles above that city, represents a total available power of 14,000 HP., of which 6,000 HP. is to be utilized at once. A dam about 50 ft. high will be thrown across the river, a length of about 1,100 ft.; it will be built as an overfall dam on its entire length. It is to be of Cyclopean masonry, with facings of concrete; at the curve of the toe the concrete will be protected against erosion by steel rails, bent to the curve, embedded in the concrete flush with its surface. The turbines are planned to be used in units of 2,500 HP., each unit being a pair of inward flow turbines on a horizontal shaft. The ultimate development (14,000 HP.) will employ seven units. Two exciter units, each 250 HP., consist of single turbines. The electric generators coupled to the main turbines are 1,500-KW. alternators of the revolving field type, producing current at 2,200 volts pressure, 60 cycles per second. At the beginning all the power will be used for local manufacturing, but if a sufficient demand arises, the current will be transmitted to Atlanta and other places in the vicinity, being transformed to 22,000 volts for this purpose. The Atlanta Water & Electric Power Co. is undertaking the development. Mr. S. M. Smith, of York, Pa., is president of the company. The hydraulic construction work will be done by the S. Morgan Smith Co., of York, Pa., and the electrical machinery will be furnished and installed by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa. The engineers for the owners are Messrs. Westinghouse, Church, Kerr & Co., of New York N. Y. We are indebted for the information contained in this note to the Westinghouse Company's Publishing Department.

LIGHTING AND HEATING BY MODERN METHODS are two of the novel features embodied in the new plant of the Lunkenheimer Co., of Cincinnati, O., makers of brass and iron steam goods. Nernst lamps are used throughout; the better color value of their light, and the satisfactory lighting distribution which they make possible, were the determining factors in their adoption. The work of this company is largely on small parts, yet not of such delicate nature as to call for bright individual illumination; these conditions made the second of the above factors an important advantage. The heating of the plant is by hot air. To save the space which would be taken up by the sheet-metal risers commonly used, the main (steel) interior columns of the building were utilized as distributors. The columns are hollow, and openings were made in them at each gallery level; the heated air is led to these columns by underground ducts and passes up their interior to the outlet openings at the various floor levels.

SPECIAL DETAILS IN A BOILER SHOP, recently built in Alsace, Germany, may be noted as follows: The floor of the shop is made of clay mixed with cast-iron chips and turnings, the mass being tamped in place; only in front of the work benches, which are ranged along the side walls, is a flooring provided, this being of pine plank on oak joists. The roof of the shop is of interlocking tile, and the inner surface is covered with hard plaster; numerous skylights are provided. A special arrangement was adopted for the uptakes from the hoods over the forges, in order to avoid cutting the roof for them. The forges are set in the side bays, near the outer wall, and the hood over each forge projects out from the wall awning-fashion, connecting with an uptake flue formed in the wall. The flue has a cleanout opening on the outside of the wall. A system of conduits is formed in the floor, serving in common for all the distribution systems, viz.: a low-pressure air supply for the blast of the forges, a high-pressure (45 lbs.) air supply for pneumatic hammers, a service-water supply, a pressure-water supply (1,500 lbs.) for the hydraulic machinery, and a return for the pressure water. The shop is fitted out plentifully with cranes. The one in the central bay, 20-ton, is a three-motor electric traveler. The transverse traveler over the large riveting machine has a motor for the trolley-travel, while the bridge-travel and the hoist are hydraulic. A large number of small hand travelers are arranged in the side bays of 2 to 3-ton capacity, and 10 to 14-ft. span; these cranes are of special low design. Jib-cranes serve the annealing furnace, etc.; these are also of 2 to 3-ton capacity, but have electric drive. The power supply to the plant is 240-volt electric current, furnished by underground cable from the power house of the plant. The pressure, air and water are supplied by motor-driven pumps. The motor equipment of the shop includes 22 motors of 170-HP. aggregate; slow-speed motors are used, generally mounted direct on the shafts. The current consumption of the shop varies from 150 to 200 amperes, which is increased to 200 amperes by the lighting.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Baltimore & Ohio R.R. near Meyersdale, Pa., on Nov. 3. A fast freight train ran into the rear of two helping engines, and engines and train were badly wrecked and partly burned. Three persons were killed in the accident.——Several other railway wrecks more serious than usual occurred. A passenger train on the Wheeling & Lake Erie R. R. ran over a misplaced switch at Coshocton, O., on Nov. 4, and collided with some cars on the siding. At least two persons were killed. On Nov. 8 a freight train on the Cincinnati, Hamilton & Dayton Ry. ran into a work train near Indianapolis, Ind. killing two men. The Norfolk & Western Ry. had two fatal accidents on the same day, Nov. 9. An eastbound passenger train ran into a stalled freight near Williamson, W. Va., the signals being obscured by fog; two persons were killed. A westbound passenger train was derailed, in part, near Bluefield, W. Va., and the engineer and fireman were killed.

ANOTHER LOCOMOTIVE BOILER EXPLOSION is to be added to the two reported in our last issue. An engine on the logging road of the Rentz Lumber Co., near Swainsboro, Ga., blew up while hauling a heavy train of logs to the mill. The engineer and two others were killed.

A WAREHOUSE FLOOR FAILED in Minneapolis, Minn., on the morning of Nov. 7. The building was six stories high, and was used for the storage of groceries on the upper and hardware on the lower floors. A section of the sixth floor gave way under its load and in falling crashed through the floors below to the ground. No one was killed or injured in the collapse. The building had brick walls and wooden column, beam and floor construction. The floor beams were joined to the walls and the posts by pressed steel stirrup hangers. It seems probable that the accident was due to the failure of one of these hangers. The accident is now being investigated carefully. We expect to present a full report in our next issue.

A CATTLEGUARD COMMISSION has been appointed by the Canadian government to pass upon the efficiency of cattleguards used by the railways. The commission is composed of Mr. F. W. Holt, C. E., and Mr. George Robinson and has its offices at Ottawa. According to a circular issued by the commissioners for the information of designers and inventors, a cattleguard to be accepted by them must be tried by actual experience on some railway to discover its adaptability to the track and must fulfil as nearly as possible the following conditions:

1. It must not be of such form or construction as to cause the derailment of trains, or to cause any greater risk to a derailed train than if the cattleguard was not in place.
2. It must be as efficient as practicable in turning stock.
3. Quietness under a fast train is desirable; that is, it should not rattle or cause other noise when a train passes over it.
4. It should not be liable to disarrangement under the conditions of use, and consideration should be given to the fact that brake gear, etc., is sometimes dropped so low as to be in danger of tearing up projecting parts if not guarded against.
5. The matter of first cost and expense of maintenance should be given careful consideration, as well as facility of repair by section men, and also the facility of keeping the track at the cattleguard in equally good condition with that of the adjoining track and roadbed.
6. The cattleguard should be easily and safely passed by trainmen or sectionmen on foot.

A MASONRY ARCH BRIDGE across the Rhone, at Valence, France, is being built to replace the two-span suspension bridge which has been in service since 1830, but is now failing through settlement of the anchorage abutments. The new arch bridge will have four spans of 50 m. (164 ft.), supported by a center pier 6.7 m (21.97 ft.) thick and side piers 4.7 m. (13.41 ft.) thick, making the total length of the structure 216.1 m. (708.8 ft.). The bridge carries a roadway 5.6 m. (18.4 ft.) wide, and two sidewalks each 1.6 m. (5.24 ft.) wide. The construction of the arches is somewhat peculiar. For that portion of their width coming under the roadway the arch-ring is a circular arc at the crown, while the haunches are parabolic arcs; for the two side portions under the sidewalks the arch-rings are circular arcs throughout and consequently of greater span then the central portion, with its parabolic haunches. A vaulted intrados connects each side arch-ring with the center arch-ring. The foundations for the piers are pneumatic caissons.

IN HIS REPORT TO THE SECRETARY OF THE NAVY, Engineer-in-Chief George Melville recommends that graduates of technical colleges be given a chance to compete for naval commissions, and that promotion be denied line officers who do not take their turn at engineering work. He condemns the act of Congress under which every naval officer of the line must become a fighting engineer.

A DEEPER HARBOR AT SOUTHAMPTON is practically assured, the Harbor Board having voted to ask Parliament for authorization to borrow $500,000 to meet the expense of deepening the channel to 35 ft.

TWO NEW SUBMARINE BOATS of the Holland type will be ready for their official trial on Monday next. They are the "Adder" and the "Moccasin," each 63½ ft. long, 11¾ ft. in diameter, and having a displacement of 122 tons submerged. They will be required to average 8 knots afloat, 7 knots awash and the same submerged. The gas engine is 160 HP., and each has a 70-HP. motor fed by batteries of 1,940 ampere-hours. Five Whitehead torpedoes are carried by each boat, and after a two-mile run in which the boat is to come to the surface but three times, a target 15 ft. deep by 150 ft. long must be struck by a torpedo.

THE MESABI IRON ORES, which last year furnished 32% of the total iron produced, are said to be controlled by the United States Steel Corporation and James J. Hill, who own 85% of the ore lands. Mr. Hill has recently purchased millions of dollars worth of Mesabi Range property. It is also stated that the expenditure of $1,000,000 in prospecting the Mesabi Range last year has brought to light only one or two unimportant deposits, from which it appears that the Mesabi Range has been pretty well defined.

THE COAL PRODUCTION OF THE WORLD for 1901 was 866,165,000 short tons, of which the United States produced 34%, the United Kingdom 28%, and Germany 19.2%. These three nations, having but 10% of the world's population, produced 81% of the total coal mined. In 1850 the world's coal product was 1-10; in 1860, 1-5; in 1872, ⅙; in 1883, ⅓, what it was in 1901.

A NEW FRENCH AIRSHIP, made by Lebaudy Bros., received its first test Nov. 2, when at a height of 60 ft. it was propelled against the wind, making at times a speed of 25 miles an hour, it is said. The airship was restrained by ropes from ascending higher. The Lebaudy balloon is similar to that of Santos-Dumont, but twice as large, being 33 ft. in diameter and 193 ft. long. The car is 16½ ft. long and holds three men. A 40-HP. motor drives the propellor.

AN INDUSTRIAL EXHIBITION at Johannesburg, South Africa, to be held in 1904-5, is planned, and a prospectus has been published outlining the character of the manufacturing exhibits desired. It is expected that the managers of the exhibition will establish an American office soon.

THE NEW YORK RAPID TRANSIT RAILWAY.

XIII.

Contract Sections VI-a and VI-b.

Contract sections VI-a and VI-b of the Rapid Transit Railway were in the hands of one contractor, and the same methods of work were employed on both; they will therefore be described together, and without distinction. Beginning at 60th St. and Broadway, Section VI-a extends to 82d St. and Broadway, where Section VI-b begins and continues to 104th St. The subcontractor for the two sections was William Bradley, of New York city.

MATERIALS PENETRATED.—The subsurface materials which underly Broadway from 60th to 104th streets is earth covering mica-schist rock. Generally the earth and rock to be taken out were of about equal depths. The earth consisted chiefly of good loam carrying very little water, and the rock was a stratified mica-schist, somewhat friable in places, but generally hard, which cut the subway excavation in strata varying from 85° to the vertical in dip from west to east. The inclined strata were generally found at the west side of the excavation, and the vertical strata at the east side.

SUBWAY STRUCTURE.—It will be recalled from a previous article that just before 103d St. is reached the four-track main line of the Rapid Transit Railway bifurcates into a two-track and a three-track line, one of which continues north and west and the other of which branches east and north. This introduced a modification in the standard subway construction from a point north of 96th St. From the center line of 60th St. north to a point about 90 ft. north of 96th St., the subway structure is the standard four-track construction. At a point about 90 ft. north of 96th St. the two middle tracks begin to descend on a 0.45% grade, and the two outside tracks begin to ascend on a 1.4% grade. This separation in the levels of the center and outside tracks continues until the difference in level is great enough to permit the center tracks to pass under the side tracks with sufficient clearance for cars. From this point on the subway continues as a double-deck structure with two tracks on each side until the station between 102d and 103d streets is approached. At about 100th St. the two outside tracks a and b swing together, as shown by Fig. 73, to pass through the station and into the west

Fig. 73. Diagram Plan of Tracks at and on Each Side of 103d St. Station.

branch, continuing along Broadway, and a third track, c, is introduced and pursues the same route. The two inside tracks, d and e, on the lower level, continue through the station and curve into the east branch, and have a third track introduced, as indicated from the point f, to the point g. The illustration, Fig. 73, is purely diagrammatical and is not to scale.

Turning now to the details of the construction by which the previously described separation of the tracks is accomplished, the drawings of Figs. 74 and 75 may be consulted. Fig. 74 shows a longitudinal and several transverse sections of the structure, beginning at a point north of 96th St., where the lower tracks have descended to a level at which the double-deck structure is nearly ready to be commenced. At section A B the tracks on the lower and upper levels are not yet separated by a deck flooring; at section C D the deck flooring has been introduced, but there are yet only two tracks on each level. Passing on to section E F, it will be seen that the third track has been introduced onto each level, room for the third track on the lower level being secured by the addition of a side bay of steelwork. The widening of the lower deck is continued through sections G H and J K, until at section L M the two decks are of the same width, and a symmetrical double-deck subway structure has been secured. The symmetrical structure continues until the 100th St. station is approached. Here one row of columns in the lower deck is removed and the construction changes to the form shown by Fig. 75, where the elevated roof in the longitudinal section indicates the beginning of the station opening. Fig. 76 is a view of the subway structure between 99th and 100th streets, looking south, and showing the depression of the center tracks.

STREET AND ADJACENT STRUCTURES.—Broadway, between 60th and 104th streets, is an avenue having a width of 150 ft., made up of two 24-ft. sidewalks and a roadway 102 ft. wide. In the center of this roadway there is a line of parkways 22 ft. wide on each side of and close to which there is a conduit electric railway track. The subsurface structures of the street consisted of water mains, sewers, and conduits, some of them being of considerable size and requiring special provisions for their care during construction, as is described further on. Of the above-surface structures only one, the elevated railway crossing near 65th St., required special support during construction. The buildings bordering the avenue are of ordinary size, and, except that many of them were fine houses and apartments whose occupants were prone to complain of the noise and dust of the subway work, they introduced no complications into the work.

METHODS OF WORK.—The general method of work on Sections VI-a and VI-b was to open up a trench the full width of the parkways and to subgrade and to widen this trench each way to

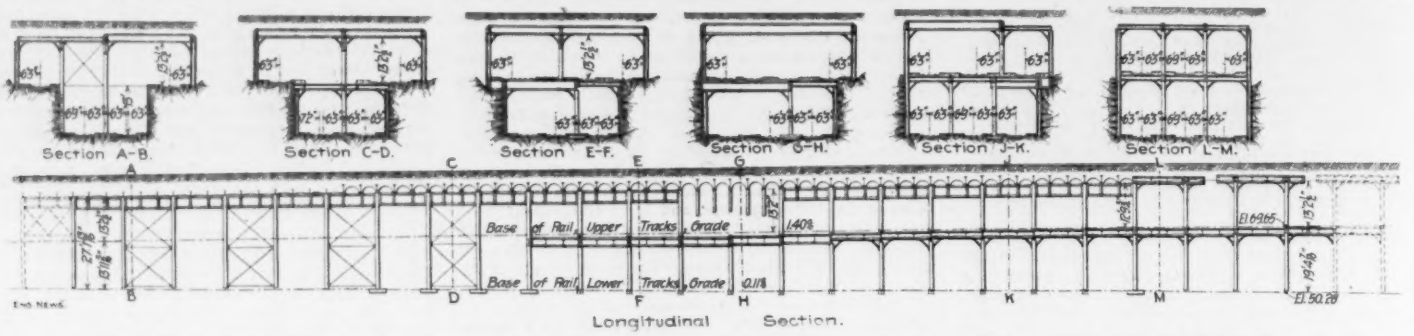


FIG. 74. LONGITUDINAL AND TRANSVERSE SECTIONS OF SUBWAY STRUCTURE APPROACHING 103D ST. STATION.

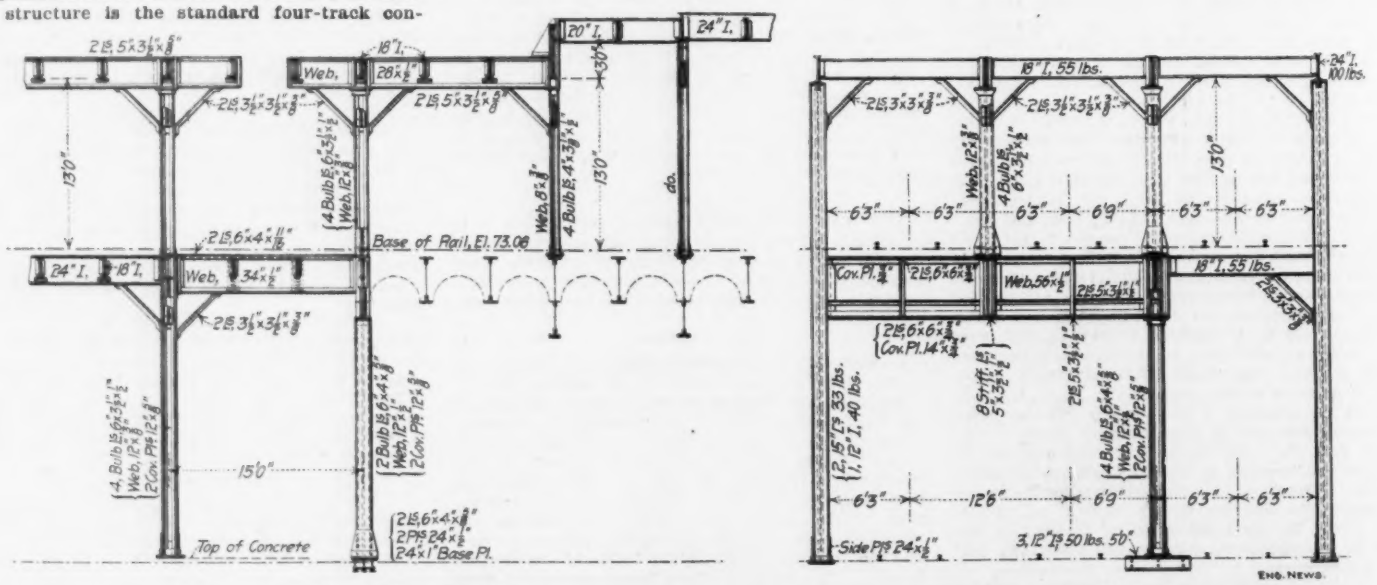


FIG. 75. SUBWAY STRUCTURE AT SOUTH END OF 103D ST. STATION.

to 79th streets, and bring out the character of the excavation very clearly. Between the two tracks will be seen the opening trench in the parkways, and on the outside of the tracks are shown the surface openings of this original trench widened to the final sidewalls. Between the sides of the

FIG. 77. VIEW FROM 72D ST., NORTH.

FIG. 78. VIEW FROM 72D ST., SOUTH

FIGS. 77 AND 78. GENERAL VIEW OF SUBWAY WORK BETWEEN 59TH AND 79TH STREETS.

final excavation and the curb enough space remained for the wagon traffic of the street, and the sidewalks were not disturbed at all. With this general explanation the detail of the various operations and their sequence can be taken up intelligently. First, it should be explained, however, that excavation was begun at a number of places along the street which were gradually extended in length until they joined.

For sake of simplicity, the sequence of operations at one point of excavation will be described first and are illustrated diagrammatically by Fig. 79. The first step was to open up a short length of street to a depth of 4 or 5 ft., and for the full width of the subway, except under the street car tracks. On the bottom and at each end of this shallow pit there were built four timber cribs in a transverse row. The arrangement of the cribs in each row was such that one corner on each side of and close to each car track, as indicated at A, B, C, D, Fig. 79a. The tops of these cribs were made flush with the street surface, and on them were set two pairs of trusses, one truss close to and on each side of each track, as is indicated by Fig. 79b and c. This first position of the trusses has been indicated by dash lines.

After the trusses were in position as described, excavation was resumed in the parkway space between the car tracks and the pit was gradually sunk to subgrade. As the pit deepened its sides gradually undermined the adjacent car tracks, and as fast as the material caved out sufficiently timber needles were thrust endwise under the concrete foundation and conduit structure of the tracks. The ends of these needles were then caught up on each side of the track by stirrups and hung to the chords of the trusses above. The needles were spaced 5 ft. apart, and were drawn tightly up against the bottom of the track structure so as to transfer its full weight to the trusses. Excavation then proceeded to subgrade under the tracks and was carried sidewise in both directions to the full width of the subway structure. The finished excavation had the form indicated longitudinally by the line a b c d, Fig. 79b, and transversely by the line e f g h, Fig. 79c.

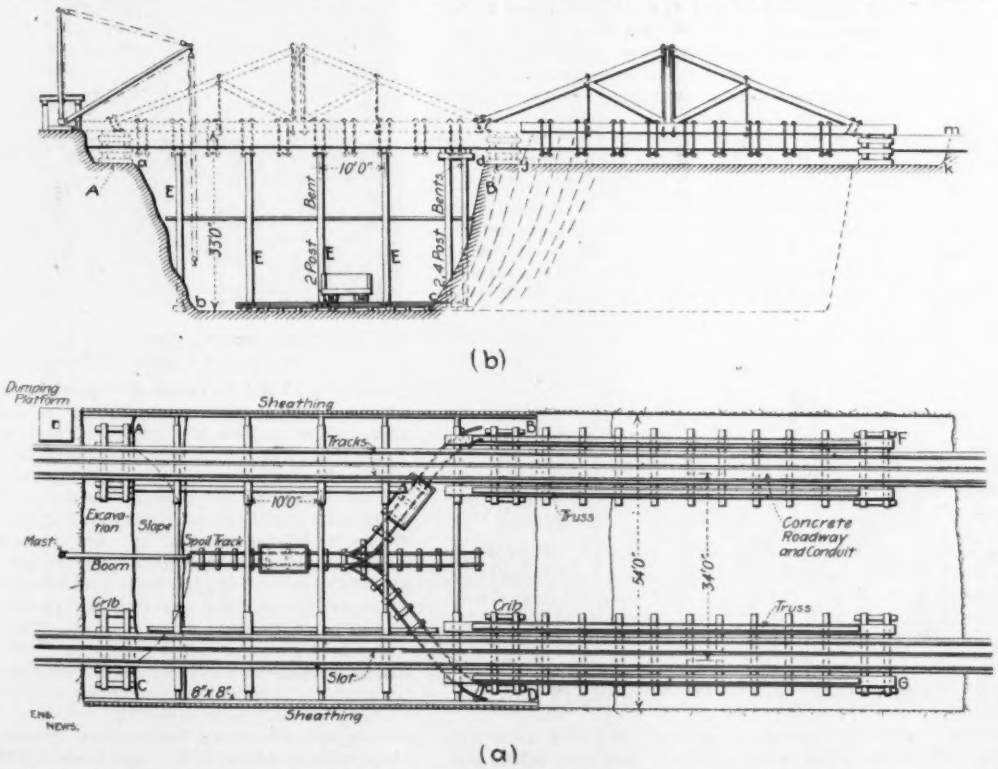


FIG. 79. DIAGRAM ILLUSTRATING METHOD OF EXCAVATION ON SECTIONS VI-a AND VI-b.

The next step was to open up another length of street, and to do this the trusses had to be freed and moved ahead. To free the trusses trestle bents were built under alternate needles and down to subgrade, as shown at E, E, etc., Fig. 79b and c. These bents were all two-post bents except that nearest the forward end of the truss, which was a four-post bent designed to carry blocking on its top. As soon as these bents were in position the stirrups were released and the trusses were free to be moved. To prepare for their movement a surface cut 4 or 5 ft. deep was made, as already described, ahead of the finished cut as indicated by the line j k m, Fig. 79b. Cribs F and G were constructed. Two low flat cars were then run between a pair of trusses and placed one at each end. Transversely across each flat car two I-beams were set so that their ends projected through the trusses just over their bottom chords. The chord on each side was caught up and hung to the projecting I-beams by stirrups. Two 6-ton jacks on each car then raised the I-beams about 3 ins., and swung the trusses clear of the cribs A, B, C and D. The cars were then moved ahead until the forward ends of the trusses

were over the cribs F and G, and the rear ends were over the four-post trestle bent on which blocking had been placed to receive them. The jacks then lowered the I-beams and set the trusses on their new supports.

The next task was to excavate the second length of street commanded by the trusses in their new position, which is shown by the full lines of Fig. 79a and b. This excavation progressed by breaking down the face c d, Fig. 79b, gradually under-

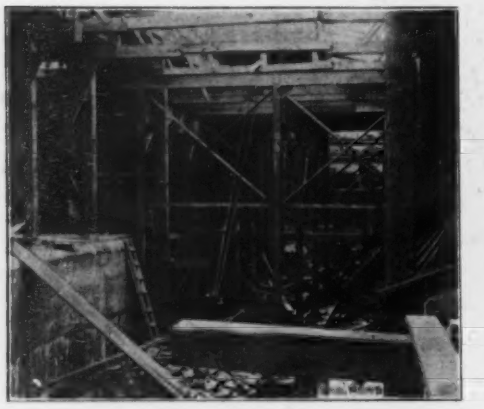


Fig. 76. View of Subway Steelwork for Depressed Center Tracks.

mining the car tracks from d toward k. As each short length of 5 ft. was undermined needles were inserted under the track structure and suspended by stirrups to the truss chords, as previously described. When the excavation had been carried to subgrade the full length of the truss trestle bents were erected under alternate needles to free the trusses, and they were moved ahead another length for the making of a new cut.

For the sake of clearness, the several operations noted have been described as taking place in succession. As a matter of fact, some of them were carried out simultaneously. The method of handling the spoil is indicated by Fig. 79a and b. As will be seen, a derrick was mounted at the rear end of the first cut and a spoil track was laid in the bottom of the cut. The forward ends of this spoil track system reached to the working faces where the cars were loaded and then run back within range of the derrick, which hoisted the boxes and dumped their contents on an elevated timber platform, from which it was taken by wagons. Besides the derricks, which were generally used, the contractors had four Lambert cableways in operation for handling the spoil. In economy of handling the spoil it was found that there was not much choice between the cableway and the derricks.

The trusses used for carrying the car tracks differed in construction; 44 were timber king-post trusses of the construction shown by Fig. 80; 12 were second-hand steel bow-string trusses, and

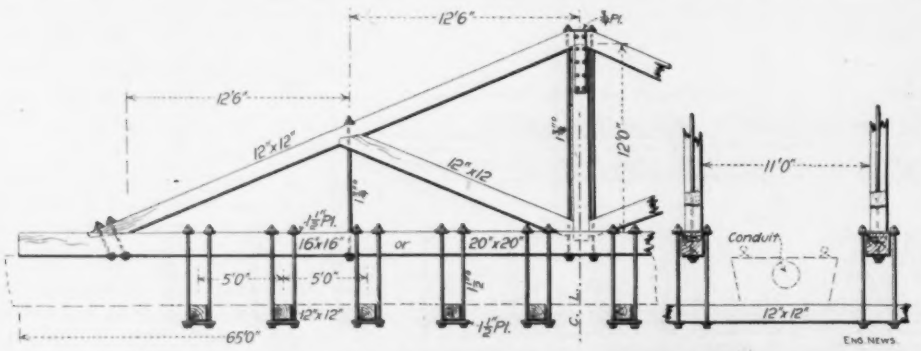


FIG. 80. DETAILS OF 50-FT. KING POST TIMBER TRUSS FOR CARRYING CAR TRACKS.

eight were second-hand steel Pratt trusses. Altogether 64 trusses were employed, or 16 sets of four trusses, making possible the excavation of 16 cuts at intervals along the work. For general efficiency and convenience the wooden trusses especially designed for the work were found preferable to the second-hand steel trusses. The wooden trusses were 65 ft. long over all, and had a truss span of 58 ft.; the steel trusses were 54 and 85-ft. span. Fig. 81 shows a set of the steel bow-string trusses in position, and beyond them appear several sets of timber trusses.

Owing to the methods of excavation and of supporting the car tracks, the excavation was left unusually free for the erection of the subway structure. The concrete floor was first placed and the column footings set. The steelwork was then erected and the concrete sidewall jack arches and roof arches were built. The concrete for the flooring was mixed in gravity mixers, the raw materials being dumped in at the street surface and the mixed concrete delivered at the floor level. For erecting the steelwork pneumatic tools were largely used; they received their air from a central power plant and also from a portable kerosene engine compressor plant, which was moved along the work as desired. Fig. 82 is a view at the bottom of the excavation, showing the first layer of the concrete flooring in place and the laying of the waterproofing in progress. The method of rolling out the felt and of swabbing it with the tar preparation is clearly indicated by this drawing. Fig. 83 is a view of the top of the completed roof of the subway, showing the piers of rubble and brick masonry which were built on it to carry the street railway tracks.

ELEVATED RAILWAY SUPPORTS.—At 65th St. the three-track line of the Ninth Ave. elevated railway crossed the line of the subway on a skew, four columns of the elevated structure coming over the subway excavation. These columns had, of course, to be temporarily supported during the excavation. At this point the elevated construction is as follows: The columns support transverse girders 22 ft. long and 4 ft. deep, and these girders carry six longitudinal girders directly over which come the track rails of the three tracks. The longitudinal girders are all riveted lattice girders. The transverse girders have solid web end panels and lattice interior panels, and the columns come under the center of the webbed end panels. To relieve a column of its load the transverse girder was extended by riveting to its end a plate girder about 13 ft. long, as shown by Fig. 84. Under the end of this girder was placed a timber support constructed as shown by Fig. 84, and resting on a grillage in the bottom of the subway cut. For two of the columns these timber supports came outside of the line of the trench and additional excavation was made for them as it was not deemed wise to support them on the street surface so near the edge of the trench. The timbers were so placed as not to interfere with the erection of the subway steel. This construction was repeated at each of the four columns of the elevated structure which came over the subway.

RECONSTRUCTION AND SUPPORT OF PIPES.—A number of subsurface pipes extending along Broadway and crossing that thoroughfare had to be reconstructed. At 71st St. a crossing 4 ft. water main was divided into two 36-in. pipes over the roof of the subway, and then these two 36-in. pipes were combined into one 48-in. pipe on the other side. The same method was adopted at 66th St. to carry a 30-in. and a 36-in. gas main across the subway, and at 96th St. to carry a 36-in. water main. For about 46 blocks a 20-in. water main along Broadway was rebuilt about 40 ft. distant. The method of construction was to build the new main in sections of several blocks, making temporary cross connections with the old main at the ends of the new pipe. The old pipe was then torn out in sections of corresponding length. In another place a 36-in. main was shifted sidewise to a parallel location 5 ft. away. The pipe was moved while under pressure by means of jacks, as shown by Fig. 85 and also by Fig. 77.

Fig. 81. View Showing Method of Supporting Car Tracks from Trusses.

PLANT.—At the beginning of work on Sections VI-a and VI-b the rock drills, hoisting engines and other machinery were operated by steam from portable boilers. Two 13-HP. Hornsby-Akroyd oil engines were used, one to run a portable centrifugal pump outfit, and the other to run a portable air compressor outfit. In November, 1901, a central compressed air power plant was put in operation. This plant is located in a power house, 88 × 45 ft. on the bank of the North River, just north of 76th St. It consists of three Rand straight-line, 24 × 30-in. air compressors, receiving steam from five locomotive boilers. The compressors have a combined capacity of 4,255 cu. ft. of free air per minute, at 90 lbs. pressure, and they

Fig. 82. View Showing Method of Laying Waterproofing on Floor of Subway.

pump to a 15 × 4-ft. receiver. From the receiver an 8-in. pipe extends north 675 ft. to 79th St., thence east on 79th St., 1,250 ft., to Broadway. From this point a 6-in. pipe runs north on Broadway to 82d St., and an 8-in. pipe runs south to 72d St. The pipe going south reduces at 72d St. to 6 ins., and then to 5 ins., and 3 ins., and, finally, to 2½ ins. at 62d St. The old portable steam plant was continued in use at the north end of the work, but practically all the machinery south of 82d St. was operated by air from the central power house.

The field plant operated consisted of 75 Rand drills, 20 Lambert 7 × 10-in. derrick engines, four Lambert 8 × 12-in. cableway engines, eight 7 × 3½ × 12-in. Cameron pumps, one 14 × 8 × 13-in. Cameron pump, pneumatic tools, stone crusher, etc.

The work of Sections VI-a and VI-b was carried out under the direction of Mr. Alfred Craven, M. Am. Soc. C. E., Division Engineer for the Rapid Transit Commission, and Mr. R. G. Collins, engineer for the contractors.

WATERPROOF WRAPPING FOR THE CABLES OF THE NEW EAST RIVER BRIDGE.

By Wilhelm Hildenbrand, M. Am. Soc. C. E.*

The necessity of protecting iron and steel structures from corrosion is particularly of vital importance in cases where the single construction members are of small sections and, at the same time, inaccessible to inspection. These two disadvantages are probably more apparent in wire

Fig. 83. View of Roof of Subway, Showing Masonry Piers Under Car Tracks.

cables for suspension bridges than in any other detail of bridge or building construction. Considering that the safety and existence of a suspension bridge depends entirely on the strength and soundness of its cables, it is natural that cable builders have always paid anxious attention to the preservation of each single wire, as well as to the application of means for preventing water from penetrating to the interior of the cables.

A cable consists of thousands of small wires, generally not over 3-16-in. in diameter, which are squeezed into a cylindrical form and firmly clamped or tied together. Only the outside wires, which in large cables comprise not over 5% of the whole number, are visible or accessible to inspection and to anti-rust applications, while all inside wires, or about 95% of the cable, must, for their preservation, rely either on their original anti-rust coating or on the best possible exclusion of moisture from the interior of the cable.

The superiority of steel wire and the economy in its use for constructive purposes is principally due to the favorable proportion of the strength of the wire compared with its weight, this being from three to five times greater than that of any other building material, or of steel in any other form than wire. On the other hand, the proportion of exposed surface of wire to its sectional area is very unfavorable. It is about twenty to one, while in ordinary structural work it is only two to one or in some cases less than one to one. The damaging effect of oxidation is therefore from 10 to 20 times greater in wire than in other steel work, and if wire could not be protected from the corroding influences of air and water its utility as building material would be very limited and it would be unfit to form a part of permanent structures.

Fortunately there are efficient means for protecting wires and cables from oxidation, as is demonstrated by the existence of numerous wire suspension bridges, which belong to the oldest structures in the country. The wires in the cables and suspender ropes of these old bridges are still in a perfect state of preservation, with no indication to show that the original condition of the wires had changed or would be liable to change at a definite period.

The simple means employed for preserving these old bridges have, in course of time, been improved and modern inventions have added new means, so that at present there is no apprehension felt for the durability of wire cables, and the only question with engineers and cable builders is: Which of the known means will suit best the given conditions or will be most economical? In deciding these questions it may naturally be supposed that it becomes often a mere matter of opinion or personal preference, in absence of experience or of facts which clearly prove the superiority or inferiority of one or the other known rust protectors.

The method decided upon for preserving the cables of the New East River Bridge is radically different from anything done hitherto, but, while it has the credit of novelty and the probability of success, it is still lacking the test of time.

For the past 50 years or more all large wire cables have been protected from atmospheric influences by a method originated by John A. Roebling, that pioneer of wire suspension bridges, whose spinning-in-the-air process of cable-making has never been surpassed, and which was repeated in its main features in the construction of the New East River Bridge cables.

At the time of the early bridges built by Roebling, the use of steel for building purposes was unknown, and the art of galvanizing metal as a rust protector was not yet invented. The wire for those bridges consisted of bright iron wire, which was treated in the following manner: Each ring of wire was dipped twice in boiled linseed oil, the second dipping being done after the oil of the first dipping was thoroughly dried. These two immersions in oil, after the latter became perfectly dry, surrounded the wire with a gummy film, to which a third coat of oil was added by passing the wire through an oil-saturated sheepskin, when it ran off from the drums for cable-spinning. After a number of wires were united and tied into a "strand" the latter received another thorough soaking of oil, which added a fourth coating and gave assurance that any spot of a wire from which the oil film might have been scraped off during cable-spinning was covered with at least one coat of oil.

A cable in which every wire is prepared as indicated above may be considered tolerably rust-proof for years if kept properly painted, but permanent safety can only be obtained by excluding all moisture from the interior of the cable, which requires a watertight and airtight covering. Such a covering was given by Roebling to all of his cables by a tight and continuous wire wrapping over the whole length of the cable, exempting only those parts which rested in the saddles or passed around the end shoes. The wrapping was put on with a specially constructed machine, worked by hand, preceded by strong clamps which squeezed the bundle of strands into a cylindrical form of the required diameter. The wrapping wire was underlaid with a thick coat of white lead mixed

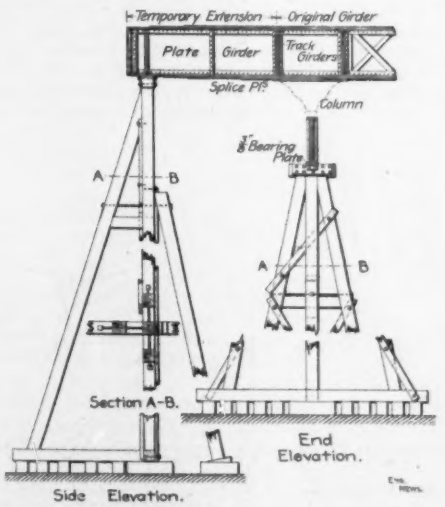


Fig. 84. Sketch Showing Method of Supporting Elevated Railway at 59th St.

with linseed oil, and a similar coat was applied to the top of the wrapping. After that the cables were painted with metallic or oxide paint of any desired color. The paint was put on thick enough to fill the hollows between wrapping wires, making the surface of the cable practically smooth and giving it the appearance of a solid cylinder.

Of notable bridge cables, treated in the above described manner, may be mentioned the Niagara Bridge, the Monongahela and Allegheny bridges, at Pittsburg, and the old cables of the Cincinnati Bridge. The former three bridges have been taken down after having done service from 42 to 46 years, and the wires of all cables were found to be in a perfect state of preservation. Also, the original cables of the Cincinnati Bridge, now 37 years old, are still perfectly sound, and the only

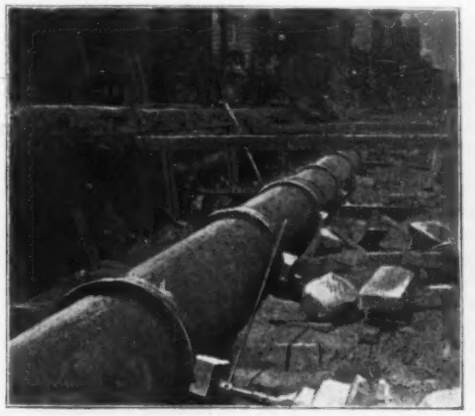


Fig. 85. View Showing Method of Moving 36-in. Water Main Sideways.

rust found in these cables, as well as in those of a number of smaller bridges which have been examined by the writer, was in those parts which were not wrapped. The old Brooklyn Bridge was the first suspension bridge in this country which was exposed to salt water air, and its builder, Mr. W. A. Roebling, felt apprehension about the reliability of his father's methods of cable protection under the aggravated conditions caused by salt water air. As the art of galvanizing steel was by this time a common practice, it was decided to have all wires, for the cable as well as for the wrapping, galvanized, as an extra safeguard in addition to every and all means employed formerly. The Brooklyn Bridge cables are now 24 years old, and, according to a recent inspection, they are as free from oxidation as when new. Whether this is due to galvanization, or whether the same result might have been obtained without galvanization, nobody can tell.

In the new cables of the Cincinnati Bridge, constructed by the writer five years ago, only the wrapping wire was galvanized, while from the cable wire the galvanization was omitted as unnecessary, judging from the good condition of the old cables, which are composed of bright iron wire. On the other hand, an innovation originated by the writer some 15 or 16 years ago, when making repairs and alterations in the suspension bridges at Wheeling and Pittsburg, was also applied to the new Cincinnati cables. It consists of filling the interstices between the wires of the finished cable with boiled linseed oil, which is poured in at the saddles and forced through the whole length of the cable. The wrapping is sufficient to keep the oil in the cable to the extent of six or seven barrels of oil for a 10-in. cable 1,000 ft. long.

As experience has demonstrated, there is no doubt that cables protected by the above described methods are well preserved and may be safe for centuries. This fact, however, is no argument for assuming that no other means of protection could be applied which might be better and would give a still greater probability of permanency. It is probable that Mr. L. L. Buck, M. Am. Soc. C. E., Chief Engineer of the New East River Bridge, was actuated by an idea of that kind when he concluded to abandon all former cable-preserving methods and to make a radical change both in the material to be used for coating the wires and in the manner of enclosing the cables with a waterproof covering. Mr. Buck's cable specification called for bright (not galvanized) wire, which was to receive two coats of linseed oil before leaving the factory, and, after the wires were united into strands, a thorough covering with a certain compound known as "cable shield,"

*Engineer for the cables of the new East River Bridge, John A. Roebling's Sons Co., South 6th St. and Kent Ave., Brooklyn.

which was to fill all the interstices in the cable. After the cable was clamped and tied with occasional wire wrappings and after covering it again with cable shield, it was to be enclosed in a sheet-iron covering. The advantages claimed for the latter, in comparison with a continuous wire wrapping, were twofold: First, it would be absolutely waterproof, and, second, it would, by the air space created between cable and covering, protect the cable from too rapid and too extreme changes of temperature. "Cable shield," manufactured by the Ironsides Co., of Columbus, O., is a mixture of pine tar, oils and other ingredients not divulged by the company. It is an excellent lubricant and rust-protector, but its consistency is too stiff and thick to permit it to be satisfactorily applied to cables. The first practical experiment made with cable shield demonstrated that it would never penetrate the interior of the cable to beyond the first or second layer of wires, and that it was even difficult to cover the outside wires satisfactorily.

The Ironsides cable shield was, therefore, abandoned and a hydro-carbon compound known as "slushing oil" mixed with 25% of artificial graphite was substituted. This slushing oil is a petroleum product, manufactured by the Vacuum Oil Co., of Rochester, N. Y. The addition of graphite gives body to the mixture and increases its lubricating qualities. Experiments made with this compound gave satisfactory results, and "slushing oil" became the material for saturating the strands and covering the cables of the New East River Bridge. To make sure that each wire in the cable would have at least one coat of slushing oil, the original plan of two coats of linseed oil in the factory was changed to one coat of linseed oil and one coat of slushing oil. The writer takes this opportunity to say that whatever the rust-protective qualities of slushing oil may be, it is certainly of great assistance in cable-making, and, in this respect, much superior to linseed oil. The gummy film of linseed oil glues the wires together, which makes the work of loosening them, when being formed into strands or at the final squeezing of the cables, very hard and difficult, while the lubricating qualities of slushing oil and graphite make that work comparatively easy and insure a tighter squeezed and more compact cable than is possible with linseed oil covered wires. On the other hand, some expectations which recommended the use of slushing oil were not fully realized. It was supposed that the compound would form a perfect and permanent coating of the wires, remaining always soft and moist, and be unaffected by heat, cold or water. Contrary to these expectations, it was learned by experience which extended over a time of five or six months that the fluid oil in the mixture either evaporated or was affected by the fumes of vessels and neighboring factories. Like other paints the slushing oil covering became dry and therefore at some places defective, requiring frequent retouching and suggesting an apprehension that, in spite of the superior qualities of slushing oil, it might not be safe to trust the preservation of the cables entirely and exclusively to the Vacuum Oil Co.'s compound. This apprehension, but still more, the consideration that the sheet-iron covering, though waterproof would not be airtight, and that the air space between it and the cable, besides its advantages, had also the disadvantage of causing the moisture of the air in that space to be condensed and precipitated on the cable, with the probability of remaining there for ever, led Mr. O. F. Nichols, M. Am. Soc. C. E., the present Chief Engineer of the New East River Bridge, to the conclusion to have the slushing oil-covered cable enclosed with some waterproof wrapping. After numerous experiments with different material, conducted by Assistant Engineer Mr. H. Robinson, it was decided to use a special cable compound, prepared on Mr. Robinson's suggestion by Edw. Smith & Co., the manufacturers of the well-known and highly-reputed mixture known as "durable metal coating."

This "cable compound" consists principally of oxidized linseed oil mixed with other ingredients and in proportions which are the inventions of Prof. A. H. Sabin, Chemist and Manager of Edw. Smith & Co. As far as can be learned it seems that the cable compound is not materially different from the durable metal paint, but it is prepared in different proportions of the ingredients and of a more solid consistency, which can be reduced to a fluid at a temperature of 350° F. The method in which this "cable compound" is used for protecting the cables and how the latter are wrapped with a waterproof material can best be understood from the following abstract from Mr. Nichols' specifications:

Each cable shall receive an additional coating of slushing oil and graphite, and then be wrapped between each pair of adjacent cable bands with 7 oz. cotton duck prepared by cutting it into strips about 7 ins. in width and filled and coated with the waterproof material herein specified.

The cotton duck filling and coating shall be the "cable compound" made by Edward Smith & Co., and the filling and coating shall be done by melting and liquifying the compound and passing the duck through it and then between rollers or similar contrivances to remove the superfluous compound.

The cotton duck waterproofing shall then be applied by wrapping continuously around each cable between the cable bands with lap enough so that there will be three thicknesses at any point, and shall be drawn or stretched tightly and shall be joined one layer to the next underneath with a hot iron or by other satisfactory application of heat.

Two coats of the Edward Smith & Co.'s "Durable Metal Coating," shall be applied to the surface of the duck covering when completed, with interval of time enough between the application of the first and second coat to allow thorough and proper drying. No painting or other work in connection with the waterproofing shall be done in damp or unfavorable weather.

The joint between the cotton duck wrapping and the cable bands shall be sealed with hot "cable compound."

The cotton duck wrappings shall extend up to and as far into the cable grooves of saddles as possible.

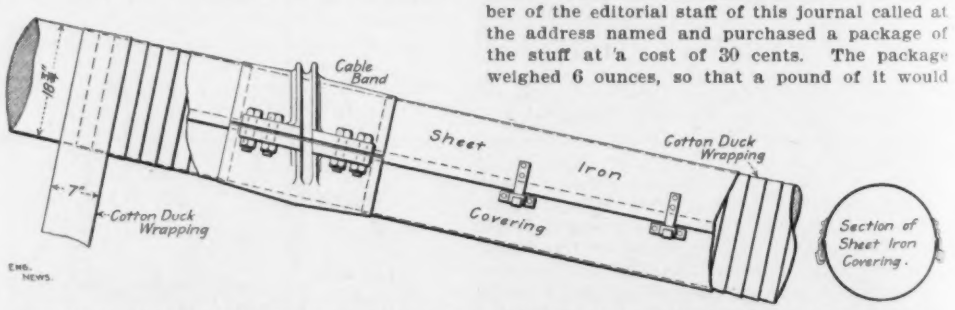
The ends of saddle grooves are thus to be closed with temporary boards fitting around the cables and against the ends of saddles. The saddles shall be poured full of the "cable compound" and the plate iron cover put on and secured with the top bolts, the seam or joint between the saddle and plate on each side being sealed with the "cable compound."

The joints between the upper and lower halves of cable band flanges or lugs shall be filled with "cable compound" as follows: The "cable compound" shall be calked or driven in with a hot or warm calking iron until the joint is thoroughly filled.

As soon as the cable bands are in place and the waterproofing applied as hereinbefore specified, the cable cover plates shall be put on, beginning at the main towers and applying them continuously towards the center and the anchorages.

The joints between cable bands and cover plates shall be calked and sealed with "cable compound" and the seams between the upper and lower halves of cable cover plates shall be coated freshly with "durable metal coating," as the plates are applied.

The contract for doing the work described in the foregoing specifications was awarded to John A. Roebling's Sons Co., of New York, which stands under the personal management of Mr. C. G. Roebling, and which, as builders of the cables and owners of the footbridge, is undoubtedly in the best position for fulfilling the terms of the specifications quicker and more economically than anybody else. Considering that it requires 9 tons of cable compound at 20 cts. a pound, and that 100,000 yds. of cotton duck tape must be wrapped around the cable with neatness and exactitude, it may be imagined that this method of cable preservation is quite expensive, costing fully as much as a wire wrapping. It has, however, the advantage of saving time in doing the work, because any desired number of cable sections between two cable bands can be wrapped simultaneously, while a wire wrapping can proceed only from four points in each cable.



SKETCH SHOWING METHOD OF WRAPPING THE CABLES OF THE NEW EAST RIVER BRIDGE.

The sheet-iron covering is made of 1-16-in. thick steel plates in two halves, the upper half overlapping the lower, as shown in elevation and section in the adjoining sketch. The two halves are joined about every 2 ft. by straps of steel, which may be riveted to the upper half and pass through lugs riveted to the lower half, as shown in sketch, or which may be loose and pass through two lugs riveted to both halves of the lower plate. The ends of the straps projecting beyond the lugs are bent over, which makes a simple and firm connection.

One cable covering section is about 20 ft. long and, as no sheet steel of that length is in the market, it is made of two lengths riveted together. The length of each cable covering section changes in every panel in the proportion as the length of the cable curve between two cable bands changes in relation to its horizontal projection, which is the same for all sections. The down-hill end of each cable band is bored wider than the diameter of the cable, for the purpose of making room for the cable covering to be inserted under the cable band for a length of 1½ ins. The up-hill ends of the cable bands fit snugly around the cable and the covering is placed over the bands with a lap of 1½ ins. This arrangement makes the water shed off at every point and no water can enter in the cable through any joint, even if the latter are not calked. With all these precautions it is doubtful in the mind of the writer whether this sheet covering alone would be as efficient as the old wire wrapping was, but in combination with the waterproof cotton duck wrapping, as described above, he thinks that air and water will be excluded from the cables as completely and effectively as they were from the dead bodies of the Egyptian kings, which were treated much in the same manner and which have lasted for thousands of years.

If the Edward Smith & Co.'s "cable compound" is what is claimed for it and what it appears to be—an impervious and imperishable coating—and with due reliance on the care and thoroughness of the men who have contracted for applying this covering, and who take personal interest in the preservation of the wires and the safety of the bridge, there is no reason for doubting that the cables of the New East River Bridge, if left undisturbed, will, like the Egyptian mummies, last for many centuries.

SOME NEW FUEL STIMULANTS.

Three or four years ago there were several attempts made to obtain money from a portion of the great gullible public by advertising the sale of some secret preparations with fanciful names, such as "Coaline," "Kem-Kom," "Kalor," etc., which were alleged to have the wonderful power of increasing the heating value of coal.* It was said at the time that one of the eastern railway companies had purchased several thousand dollars' worth of one of these mixtures for improving the combustion of coal in its locomotives.

The recent anthracite coal strike has caused the resurrection of at least one of these humbugs. There was recently advertised in the New York daily papers the merits of "Coaline," which, it was said, "saves half of all coal bills," sold by the Coaline Company, 355 Amsterdam Ave. A member of the editorial staff of this journal called at the address named and purchased a package of the stuff at a cost of 30 cents. The package weighed 6 ounces, so that a pound of it would cost 80 cents. He also obtained a circular describing the merits of the preparation, from which we quote as follows:

COALINE. (Registered.) Saves Half of Your Coal Bills. Prevents smoke, consumes coal gas, soot and cinders; keeps boiler tubes, grates, cooking utensils, stove pipes and chimneys clean; makes poor coal do the service of good coal, and is equally effective with hard or soft coal. The best and cheapest coal consumer in the world.

Coaline furnishes to the coal certain elements which are required to make a perfect combustion, and in doing so prevents cinders and consumes all the vitality there is in the coal.

Coal treated with coaline will burn more freely and at

*See articles on "Kalor, a New Fuel Fertilizer," Eng. News, June 1, 15, and 29, 1899.

the same time last much longer, because more combustible matter is burned.

Directions: Our 30-ct. package of coaline dissolved in three gallons of water and sprinkled over one ton of hard coal will make it do the work of two tons. For soft coal and coke use double the quantity of water. Where coal is used in small quantities dissolve one-half teaspoonful of coaline in a glass of water for each scuttle or pail of coal. It is not advisable to prepare with coaline more than two days' supply in advance. Should coal stand for two days after using coaline, revive it by sprinkling water over it. Non-explosive, non-poisonous. Can be handled by a child.

The 30-ct. package was examined in this office and found to consist of a reddish-brown substance, looking almost exactly like a fine sand made by crushing red sandstone, but containing a small percentage of dark purple, almost black, specks. By careful sorting of a small sample on white paper these specks, together with some black dust, could be separated from the remainder of the substance. Under a microscope the brownish substance appeared like crystallized common salt, and the dark specks showed the characteristic appearance of crystallized permanganate of potassium. On dissolving these specks in water they gave a strong purple color, and confirmed the opinion that they were permanganate. The brown crystals also were found completely soluble in water, giving a lighter or more diluted purple color, and they had the taste of common salt. Our inspection led us to the conclusion that coaline is nothing more than common salt colored by the addition of a small percentage of permanganate of potassium.

We thereupon sent a sample of the stuff to a well-known chemist, and his complete report is given below:

The sample of "coaline" received from you Oct. 17 analyzes as follows:

Sodium chloride (Na Cl)	90.3	per cent.
Potassium permanganate $K_2 Mn_2 O_8$	3.2	" "
Organic and coloring matter	6.5	" "

If this material sells for 30 cts. per lb., and much of it is sold, somebody is making money on an utterly useless mixture for heating. Thus 100 lbs. will cost as follows:

90.3 lbs. Na Cl, cost 1 ct. per lb.	$0.90
3.2 lbs. $K_2 Mn_2 O_8$, cost 9 cts. per lb.	0.28
6.5 lbs. coloring matter, at 2 cts. per lb.	0.13
Total	$1.31

which, selling at 30 cts. per lb., produces $30 for the 100 lbs. That is to say the profit is $28.69 out of every $30.

The analysis shows it to be a "fake," since sodium chloride (common salt) will not increase the heating power of coal, but will absorb heat and reduce it.

The chemist was misinformed about the selling price of coaline. It is 30 cents for a 6-oz. package and not 30 cts. per lb. Taking the selling price at 80 cts. per lb. it makes the profit $78.69 out of every $80.

Since writing the above we have learned of another remarkable new fuel fertilizer, and we regret, for the sake of engineering journalism, that we learned of it through a full-page advertisement in an esteemed and hitherto reputable contemporary. We quote as follows from the advertisement:

OXIGINE
Trade-mark Registered.
Patent Applied For.
TWELVE OUNCES TREATS A TON.
The Greatest Known Coal Saver.
SAVES ONE-FIFTH OF ALL COAL BILLS.

Largely reduces black smoke, and prevents Soot and Clinkers.

Consumes all Coal Gas and Cinders, and leaves only the shale, or slate, and fine ashes that is incombustible in all Coal.

Keeps Boiler Tubes, Fireboxes, Grates, Flues and Chimneys clean.

Will enable an Engineer to make Steam with Poor Coal, when it is otherwise impossible.

Coal treated with OXIGINE evaporates 20 per cent. more water per pound of Coal than the same Coal under like conditions will evaporate without it.

Used in Steam Plants in New York shows following results:

Here follows a list of 25 places where Oxigine is said to be used, with the reported saving of fuel at some of them ranging from 16 to 35%.

We have obtained some circulars from the Oxigine Coal Saving Co., 5 and 7 East 42d St., New York, in which the same statements are made as those in the advertisement. One of them is entitled, "Why Oxigine Saves Coal," and it contains a popular discussion of the well-known principles of combustion of carbon, together with the following statement:

The cause of so much loss of heat energy in coal is owing to an insufficient supply of oxygen. This want also permits the formation of CO, when more oxygen if present would produce CO_2.

Oxigine when added to the coal, remedies these defects in combustion, by supplying quantities of free oxygen; when CO is readily converted into CO_2, saving coal by adding this amount of heat energy.

We have not taken pains to procure a sample of "Oxigine" and have it analyzed, and so we will give it the benefit of the doubt and assume that it really is a material capable of supplying oxygen to a coal fire, and not only that, but the best imaginable material for that purpose. Let us study the arithmetic of combustion a little and see what such a material would be worth.

Suppose that in burning coal on the grates under a steam boiler the coal bed were carried so thick and the air supply were so inefficient that the furnace really became a gas producer, burning the coal only to CO instead of to CO_2, and producing only 4,450 British thermal units per lb. of carbon instead of 14,600—a waste of 10,150 B.T.U. per lb. Suppose also that the so-called "Oxigine" were really pure compressed oxygen, so that every particle of it was effective in promoting combustion. How much fuel could we save if we were able to buy such Oxigine at the low price of 25 cts. for 12 oz., or 33⅓ cts. per lb.?

For each pound of carbon, after it is burned to carbon monoxide gas, CO, there is required an additional supply of 1⅓ lbs. of oxygen to convert the gas into CO_2, or 2,667 lbs. of oxygen for a ton of 2,000 lbs of carbon. A gross ton of anthracite coal, costing say $5, would contain about 2,000 lbs. of carbon. The 2,667 lbs. of oxygen, or "oxigine," would cost $2{,}667 \times 0.33\frac{1}{3} = \$888.89$. The ton of coal, burned imperfectly to CO, would give $2{,}000 \times 4{,}450 = 8{,}900{,}000$ B.T.U., or at $5 per ton, 17,800 B.T.U. for 1 ct. If completely burned to CO_2 it would give $2{,}000 \times 14{,}600$, or 29,200,000 B.T.U., or 58,400 B.T.U. for 1 ct. The difference, 20,300,000 B.T.U., may be gained either by burning the coal properly, with sufficient air, or by using 2,667 lbs. of oxigine, costing $888.89, which is equivalent to only 228 B.T.U. for 1 ct. The "oxigine," therefore, is $17{,}800 \div 228 = 78$ times as costly for its heat-giving power as coal with its carbon burned only to CO. It is 256 times as costly as coal with its carbon burned to CO_2, and infinitely more costly than air, by which the perfect combustion of coal may be obtained just as well as with oxigine. Even if "oxigine" could be obtained for nothing, and it were really solid oxygen, 2,667 lbs. of the stuff would have to be shoveled into the furnace with every ton of coal in order to produce the same effect as a proper supply of air.

A STATE BUREAU OF HYDROLOGY has been established in Prussia, Germany, under the joint auspices of the Ministry of Public Works and the Ministry of Agriculture, Lands and Forestry. The purpose and work of the bureau is the general investigation, statistical and other, of subjects such as precipitation, runoff, river flow, ground-water flow, etc. Flood and ice statistics, being important practical matters intimately connected with the subject of river flow, are to be given special attention. The data and results obtained will be published in annual volumes of reports.

THE INTERURBAN ELECTRIC RAILWAY SYSTEM OF THE UNION TRACTION CO. OF INDIANA.

The Union Traction Co. of Indiana was organized in 1899 for the purpose of acquiring and extending some existing street and interurban railways, and is now operating an electric railway system aggregating about 154 miles, including 98 miles of interurban lines, and 56 miles of street railways in the different towns on the system. The railway had its inception in a street car and steam dummy line about seven miles long, built at Muncie, Ind., in 1889, and later extended to 15 miles. This company and the street railway company of Anderson were consolidated in 1897 under the name of the Muncie, Anderson & Indianapolis Street Ry. Co., which was to build an electric line connecting these three cities. About the same time a line was started northward from Anderson which eventually connected with another line extending south from Marion, and these were included in the consolidation. From the Anderson and Marion line there are two branches, one running west from Alexandria to Elwood, and the other east from Jonesboro to Gas City. Two other branches are also proposed, one from Linwood west to Frankton, and the other south from Daleville to Middletown. The Elwood branch is now being extended to Tipton, 10 miles, where it will connect with a new interurban line from Indianapolis to Logansport and Peru, 104 miles, which is being built by the same interests, but under the name of the Indianapolis & Northern Traction Co. The line from Anderson to Marion was opened in 1898 and the line from Muncie to Indianapolis in January, 1901.

A map of the system is shown in Fig. 1, and the distances between terminal and division points are as follows: Indianapolis to Anderson, 36 miles; Anderson to Muncie, 18 miles; Anderson to Alexandria, 12 miles; Alexandria to Marion, 34 miles; Elwood branch, 10 miles. The Gas City branch is within the city limits of Jonesboro. Besides this, the company operates local electric street car lines in Anderson, Muncie, Alexandria, Elwood and Marion. Its line terminates at the city limits of Indianapolis, but it has running powers over the tracks of the Indianapolis Street Ry. Co. to a terminal in the heart of that city. The city serves a municipal and rural population of about 175,000, exclusive of the city of Indianapolis, which has a population of about 170,000.

All the lines parallel existing steam railways: the Cleveland, Cincinnati, Chicago & St. Louis Ry. west from Indianapolis to Muncie, and north from Anderson to Marion; and the Lake Erie & Western Ry. west from Alexandria to Elwood and Tipton. The new line to Logansport and Peru will also parallel the latter railway from Indianapolis north to Kokomo and Peru, 74 miles; and the Pittsburg, Cincinnati, Chicago & St. Louis Ry. from Kokomo to Logansport, 23 miles.

The organization of this system of interurban and city electric railways is largely due to Mr. George F. McCulloch, who is now President and General Manager of the Union Traction Co. of Indiana. The other officers of the company are as follows: Assistant General Manager, A. L. Drum; Purchasing Agent and Assistant to President, C. W. McGuire; Treasurer and Auditor, W. C. Sampson; Chief Engineer and Roadmaster, W. H. Bloss; Electrical Engineer, Albert S. Richey; Master Mechanic, J. L. Matson; Assistant Superintendent and General Passenger Agent, C. A. Baldwin. The company's headquarters are at Anderson, Ind.

PROFILE AND ALINEMENT.

In general, the lines run through a flat farming country, but on the Marion line there is some broken country involving 6% grades, and as some of these occur within city limits on the lines of future streets the company cannot do anything to improve them. As a rule, however, the maximum grades are 2%, some of the bridges being on such grades. The interurban lines are laid mainly on private right of way, but strike the highways on approaching towns or villages, so as to pick up the local traffic.

For considerable distances the right of way of the electric road is adjacent to that of the steam road, partly on account of the greater ease of obtaining the land in such a condition, but it diverges from the latter at towns for the reason above noted. In certain cases the electric road is laid at the side of the public highway, but as a rule it is built on its own right of way, except through towns and villages. The location has been to a considerable extent governed by right of way conditions, a situation which does not obtain in ordinary railway practice, and which is apt to be somewhat confusing to an engineer accustomed to steam railway practice. Under the Indiana laws a street railway could not condemn land for right of way, and as the interurban lines were (and still are) classed as "street railways" they had to take such land as they could get. Many farmers and property owners refused to sell land for a right of way across their property, but would consent to sell a strip adjacent to the right of way of the steam railway, as the electric line parallels steam lines for almost its entire length. Under these circumstances the right-of-way agent did his work first, and the engineer had then to fit his location to suit the right of way. This resulted in many elbows, bends and "jogs" in the line, the reason for which in such flat country is

hard to see until the above governing conditions are explained. Plain and reverse curves of 14° to 23°, and 50 ft. radius, occur at various points, and give the line a most peculiar appearance. The width of right of way is usually only 25 or 33 ft., making it necessary to arrange the profile so that the banks and cuttings will come within the limits. In a few cases a width of 40 ft. is obtained for unusually high banks or deep cuttings.

The law has recently been altered, however, to permit electric interurban lines to condemn land, and the company is now busy buying right of way to give a proper location and eliminate some of the startling curves and the heavier grades. In many places this involves an entire change of location, tangents and easy curves taking the place of a succession of sharp curves. The intention is to limit curves to 2° on the open line, although this must be exceeded in some cases. The original right-of-way conditions did not allow of transition curves or curve easements, but in much of the improvement or reconstruction work transition curves are used, a 2° curve, for instance, being reduced at the ends to 1½° in a length of about 200 ft.

CONSTRUCTION AND IMPROVEMENT WORK.

In the construction of new lines the grading is done partly by contract and partly by the company's forces, the company owning a considerable equipment in the way of grading plows, scrapers, etc. The grading is light, averaging about 3,500 cu. yds. per mile, though it is heavier in places. Materials are sometimes carried in the steam railway cars over the line to the distributing points, the cars being handled by one of the electric locomotives. Rails are also carried on two small flat cars with swinging bolsters to allow of passing the sharp curves. In tracklaying, the ties are distributed along the grade by teams at an average cost of 3 cts. per tie, this sum including loading at the distributing point, hauling and unloading on the grade. Rails are sent out on small flat cars, as in steam railway construction. Ballast and material for widening banks is carried in trains of four-wheel side-dump cars, hauled by electric locomotives.

All improvement work, heavy track work, reballasting, changing of grades and alinement, and shifting track to new roadbed, is done at night by the company's forces. The shifting of track to a new alinement is by no means an easy undertaking, as trains run at hourly intervals during the greater part of the day, and the construction gangs have only about three or four hours at midnight in which to work without interruption. The new piece of line or "cut-off" is graded by plows and scrapers, track is laid and ballast is deposited during the day time. Poles are also set and wires are strung ready for the change. When all is ready, a date is selected for changing the line, and a number of section gangs are massed on the line about 10 p. m. They make all preparations possible before the last car passes, and then have to work hard for the few hours during which the current is shut off. While they are connecting up the track the linemen fix the trolley-wire connections. Ballasting and other improvement work on the existing line is done mainly between trains during the day, the work trains occupying the track under special orders, as in steam railway practice. The train orders are given by telephone, as will be explained later.

Much of the work of the engineering department at present is devoted to general improvements, and in a trip over the line it is interesting to compare the old and new locations. It may be noted that the old right of way reverts to the original owner as soon as its use for railway purposes is abandoned.

TRACK.

The width of roadbed at subgrade is 16 ft. and the standard track construction consists of 70-lb. rails of the Am. Soc. C. E. section, 30 ft. long, laid with broken joints and spliced with the Continuous joint, having four bolts. This joint has also been used with success on old rails worn and bent at the ends, tending to straighten the rails vertically and to take out the "cup" just beyond the end. The rails are laid on white oak ties spaced 26 ins. c. to c., with gravel ballast 8 ins. deep below the ties and shouldered out 6 ins. from their ends at the top. The ties are 6 × 8 ins., 8 ft. long, obtained from Michigan and Kentucky. This construction does not as yet exist over the whole system. On the Indianapolis and Anderson Division, there are 70-lb. rails 60 ft. long, but these long rails are not considered satisfactory, as they are awkward to handle, and are so flexible that it is difficult to maintain them in proper line and surface. These long rails are also laid with square joints and six-bolt angle bars, neither of which features meet the approval of the present officers. On the Anderson and Marion line there are some rails as light as 45 lbs. and others as heavy as 90 lbs. per yd. As different parts of the line were built by different companies at different times there is considerable variation in the track construction. Short ties and ballast only 3 to 4 ins. deep under the ties are found at different points. Under these conditions, and in conjunction with the general improvement work already referred to, the engineering department has a considerable amount of work in hand to bring the entire line up to the standard condition.

In the towns, the tracks are laid mainly with 6-in. 60-lb. T-rails, on wooden ties and 8 ins. of

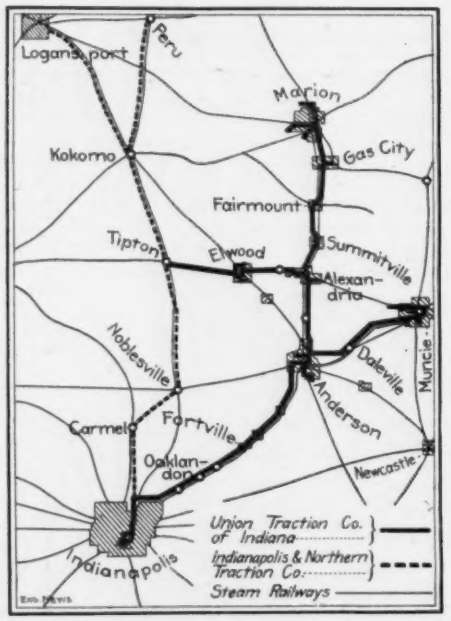


Fig. 1. Map of Electric Railway System of the Union Traction Co. of Indiana.
George F. McCulloch, President; W. H. Bloss, Chief Engineer.

gravel ballast, the streets being generally paved with brick, even in the small towns. This construction is found to be sufficiently substantial, but in some of the Indianapolis streets the track (of the Indianapolis Street Ry. Co.), is not rigid enough to carry the very heavy interurban cars, and the brick paving is being racked to pieces, especially at the rail joints. This track will have to be rebuilt. The brick paved streets are found to have been built in various ways, some with sand and some with gravel foundations, 2 to 4 ins. thick. The company does not, as a rule, maintain the paving. Part of the old line in Muncie had grooved rails, which would not admit the large flanges of the wheels on the interurban cars, which had to run over a portion of this track. In order to avoid the necessity of laying this piece of track with new rails, an emery wheel grinding machine was fitted up on a car, and the groove ground out to the necessary width and depth for about 300 ft. of track.

At Muncie, the Chief Engineer has introduced a concrete beam construction of novel design, shown in Fig. 2. The beam is 20 ins. wide, 12 ins. deep under the rail and extends 6 ins. on each side of the rail head, its surface being flush with the paving. This is in an asphalt paved street, and obviates the use of brick or stone along the rails. Asphalt cannot be maintained in good condition next to the rails, and its repair or renewal is expensive and tedious. The concrete is more durable and can be promptly repaired at very small cost. A trench is excavated for each rail and heavy stakes are driven to the grade line for the base of rail; on these the rails are laid and bolted up for one side of the track. The concrete is then placed and well tamped under the rail, a transit being used to ensure that proper line is maintained. When this is completed, and the concrete has set, this rail is used for lining and gaging the other rail, which is placed in the same way. No tie rods are used to connect the rails, except at sharp curves. This track requires special care in its construction, as line and surface cannot be rectified when it is once laid, but it is much more permanent and effects a great reduction in the maintenance work. The cost is about $1 per ft. of track for concrete and labor, exclusive of the rails. Other methods of construction of concrete foundations for street railway track were described in our issue of March 6.

The line is mainly single track, with passing sidings about two miles apart. Most of the turnouts at these sidings are equipped with split switches (15-ft. switch rails) and No. 6 spring rail frogs, this frog number being adopted for the reason that it gives a lead (theoretical) of 56.52 ft., which enables the turnout to be placed within the 100-ft. spacing of the poles which carry the electric wires. The split switches have small ground switchstands. Some of the turnouts, however, have a single switch rail, with a fixed mate on the other side, but these are not regarded with approval. On the Anderson and Alexandria division there are also some old "diamond" sidings, in which each track is offset from the center line, and the switches are set so that cars in one direction automatically take one track, while those in the opposite direction take the other track.

In paved streets, switches with pivoted tongue rails are used, and these are of a special design made to the suggestions of the chief engineer. In ordinary tongue switches, the wear and thrust of the wheels come directly upon the side of the heel, tending to displace the pivot and so causing the switch to ride badly. The tongue rail is also liable to wear and bend beyond the point, assuming a vertical concave curve. In the new style of switch, shown in Fig. 3, the tongue is 8 ft. 6 ins. long (1 ft. 6 ins. longer than usual) and is exceptionally deep and stiff, while it has a bearing on the bed of the casting for its entire length. The heel is also protected on each side by guards, so that it is not touched by the wheel flanges. These switches, as well as most of the switch, frog and crossing work on the line, were built by the Paige Iron Works, of Chicago.

There are no less than 119 railway grade crossings, none of which are protected by gates or interlocking plants, as such protection is not required by the Indiana law governing street railways, under which these electric interurban lines are built. Cattleguards also are not required at road crossings, and are only used in a few cases. Even fencing is not required by law, but the company builds a woven-wire fence along its right of way wherever the property owner will undertake to maintain the fence.

On sharp curves of 4° and over, the gage is widened ¼-in. to ½-in. on city lines; on other curves the foremen are simply instructed to spike the track to a "slack" gage. For superelevation on curves the ordinary formulas will not give satisfactory results, owing to the comparatively light weight of the car body. The maximum elevation employed is 7 ins., on a 10° curve.

The jurisdiction of the chief engineer and roadmaster covers the interurban line proper and all the city lines, with the exception of those in Indianapolis, which are not owned by the company. He has two assistants, one in charge of the track of all city or street lines, and the other in charge of the track of all interurban lines. There are 17 section foremen, with sections averaging 8 miles in length; these have three men to a gang in the country and five men in the towns. The foremen are paid $45 per month; and the men 12½ cts. per hour for 10 hours' work. Their regular hours are from 6 to 5, with an hour for dinner. When working at night, as in shifting track (already referred

to) they are usually paid for a full 10 hours' work, although their actual working time is only a few hours. Besides the section gangs there is a bridge gang and also a fence gang.

There has so far been no serious interference with traffic due to snow. Scrapers are used in the towns, and snow-plows and scrapers on the open line, while the cars will force their own way through short and shallow drifts. Salt is very

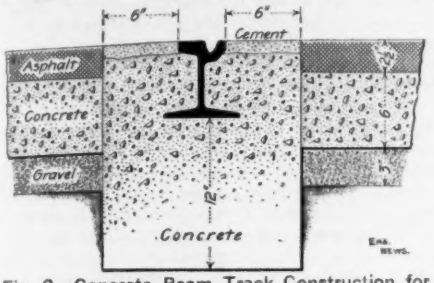


Fig. 2. Concrete Beam Track Construction for Street Railway at Muncie, Ind.

little used, and that only in emergency, mainly at switches and frogs on city track.

BRIDGES AND BUILDINGS.

There are on the line about half a mile of steel bridges and 675 ft. of pile trestle work. This is exclusive of 700 ft. of steel bridges and 300 ft. of trestles in the several towns, where the company is not responsible for them. The steel bridges are mainly I-beam structures of 15 to 20 ft. span, but include also plate girder, pony truss and through truss spans, all on stone piers and abutments. At Anderson there is a three-span truss bridge, 405 ft. long, on which the line crosses the White River. Sets of wooden frames above the trusses carry the high-tension wires, while over the approaches the regular span-wire system of supporting the trolley wire is used, as described below. The longest truss spans are 154 ft.; and at Anderson is a two-span double-track truss bridge 200 ft. long. The live load assumed in preparing the designs is a distributed load of 4,000 lbs. per lin. ft. of track, no concentrated load being considered. Most of the plate girder and truss spans have been built by the Indiana Bridge Co., of Muncie, Ind. Culverts are mainly of cast-iron pipe and vitrified clay pipe.

The power house and main car sheds, with machine shop, car repair shop, blacksmith shop and store room, are at North Anderson. The machine shop contains a wheel press, wheel lathe, boring mill, etc., all driven by an induction motor. The car repair shop is 177 × 66 ft., and has three pits. At eight points along the line are substations, as described further on. There are car sheds and repair shops at Muncie, Marion and Elwood, and a car shed at Alexandria, while at Indianapolis a car shed is rented. All of these are brick and iron buildings.

There are only two or three station buildings, and these are of frame construction, but in the principal towns waiting-rooms are provided in office or store buildings for the convenience of passengers. At road crossings, open platforms are provided.

ELECTRIC WIRING.

The greater part of the line has the No. 20 trolley wire (of "figure 8" section) attached to span wires carried by two lines of poles. These poles are of cedar and Oregon pine, and are set 6 ft. in the ground. They are spaced 16 ft. apart at the subgrade, with an outward rake of 5 ft. in their height, so as to resist the inward pull of the trolley wire. One row of poles carries the feeder and high-tension wires; these poles are 40 ft. long on the interurban lines, 60 ft. long in towns, and longer where necessary to cross telephone wires, etc. The other row of poles carries the telephone wires, and these are 30 ft. long. The poles are spaced 100 ft. apart along the line. On the Tipton extension, the bracket system of construction is being used, with 40-ft. Oregon pine poles carrying light iron bracket arms. This is now the standard construction and is shown in Fig. 4. The cross-arms for the high-tension wires on double-pole lines are of pine, the upper one 8 ft. long (with four wires), and the lower one 5 ft. long (with two wires). Porcelain insulators are used for the high-tension wires on part of the system, but on all new work glass insulators are used exclusively, being considered more efficient and also more economical.

No derrick or hoist is used in placing the poles, but they are erected simply by means of ropes and pike poles. A gang of 20 men will set about 40 poles per day (this including digging the holes), and the alinement is very accurate. The feed and high-tension cables are hauled into place by a rope 500 to 1,000 ft. long, according to the alinement, from 800 to 1,000 ft. being placed where the line is fairly straight. This rope is laid over the cross-arms, one end tied to the cable and the other end hitched to a team of horses. A lineman stays on each pole to pass the knot over the cross-arms and then goes ahead to do the same at another pole. When the span wires have been placed, a reel of the trolley wire is mounted on a truck, the wire being carried up to a tower wagon following close behind the truck. The men on the wagon secure the trolley wire to the clamps on the span wires.

The track is bonded with rail bonds of various kinds at the joints, while the rails are cross bonded at every sixth joint on 60-ft. rails.

Although the cars run regularly at speeds of 40 to 45 miles an hour, and occasionally attain speeds of 50 to 60 miles an hour, very little trouble is experienced from the trolley wheel jumping off the wire, even on sharp curves. This is especially the case where the pole and track have settled to a bearing and the trolley wire has been adjusted after such settlement.

CAR EQUIPMENT.

The rolling stock equipment includes the following: 32 double truck interurban motor cars, 20 interurban trail cars, 100 four-wheel city motor cars (open and closed), 50 city trail cars, 1 large private car for the president of the company, two motor freight cars, 1 electric locomotive of 300 HP. for gravel trains, 3 smaller electric locomotives, 1 substation car (described below), 7 tower cars, 5 electric line-repair cars, 1 electric pile driver car, 1 snow plow with motor, 5 snow plows without motors, 32 four-wheel dump cars for ballasting and filling, and 8 flat cars. The pile driver car is a double track flat car, with swinging leads 18 ft. long, braced by rigid backstays, and having a 1,000-lb. hammer; it has a reach of 16 ft., for standard trestle work. Its hoist is operated by a 35-HP. street car motor. The line repair cars are out all the time looking to places needing repairs.

The large interurban cars are 52 ft. 6 ins. long over all, 8 ft. 8¾ ins. wide, 4 ft. 7⅛-in. high from rail to floor, and 9 ft. 5 ins. from floor to top of roof. The truck wheelbase is 6 ft., and the distance c. to c. of trucks is 29 ft. 6 ins. The older cars weigh about 60,000 to 65,000 lbs., while the newer cars weigh 80,000 lbs., with 48,000 lbs. on the driving truck. This truck has two Westinghouse motors of 150 HP., one on each axle. The wheels are steel tired, 36 ins. diameter, 3 ins. wide on the tread, with flanges ⅞-in. high. The axles are 6½ ins. diameter, increased to 7½ ins. at the gear-wheel seat, and have journals 4¼ × 8 ins. The trailing truck has no motors and is mounted on 33-in. chilled cast-iron wheels. The driving trucks were built by the Baldwin Locomotive Works, and some of the older cars have motors of 100 and 125 HP. Fig. 5 is a view and Fig. 6 a plan of one of the latest cars.

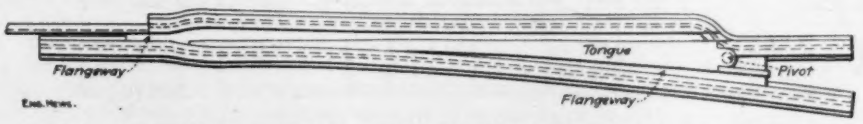


FIG. 3. IMPROVED TONGUE SWITCH, UNION TRACTION CO. OF INDIANA.
Paige Iron Works, Chicago, Makers.

These cars seat 44 persons in the main portion and 10 or 12 in the smoking room. The ordinary cars have a combination baggage and smoking room, but the fast or "limited" cars carry no baggage and have the smoking room upholstered and fitted with cane chairs. The platforms are vestibuled and the motorman's room or cab is partitioned off from the front platform. There is also a toilet room in each car.

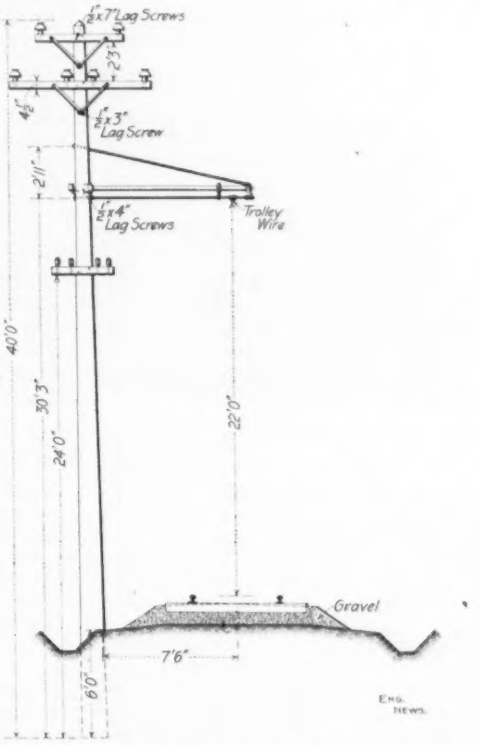


Fig. 4. Standard Pole Construction, Union Traction Co. of Indiana.
A. S. Richey, Electrical Engineer.

The height of the cars is almost equal to that of ordinary steam railway cars, which is thought to be unnecessary, while it makes the car somewhat top-heavy (especially as it is not held down by other cars as in a train), and a less lofty car would probably ride more easily on the curves at high speed. The private car is 50 ft. long, and of very elaborate finish. Its entrance is at the middle of one side; at one end are the observation and dining room (with two Pullman sleeping berths), kitchen and bath room; at the other end is an office and smoking room. Each end has a corner compartment for the motorman, with a door at the side. All of these cars were built by the St. Louis Car Co., of St. Louis, Mo.

The cars have the Baker heater, Christensen air-brake (with independent motor for the compressor), hand-brake, air whistle, air jet for sanding the rails, arc headlights and incandescent lamps. These latter lamps, however, are very trying to the eyes of passengers, as their light varies with every movement of the controller handle, varying from a dull yellow to an intensely white light. Both ends of the car have heavy bumper beams, and the front end has a strong wooden pilot or cow-catcher. The cars carry front and rear markers, as in steam railway service, and have also signs in front indicating the route and whether the car is an ordinary or "limited" car. The electric headlight is placed over the bumper and throws a brilliant light for a considerable distance ahead. In the Indianapolis streets, however, this is masked by a screen showing the route of the car. The cash register shows the amount paid for each fare, and whether the fare is cash, ticket, pass, half-fare, etc.; the amount and indication are printed on a tape in the machine.

The air brakes are graduated to give a pressure on the wheels of the front truck equal to 90% of the weight on this truck, and on the rear wheels 75% of the weight on the rear truck; this is for emergency applications. The reservoir pressure is 85 lbs., and the train pipe and brake cylinder

pressure is 20 lbs. for service applications and 40 lbs. for emergency applications. In a series of brake tests at speeds of 58 miles per hour, service stops were made in about 750 ft. and emergency stops in 500 to 525 ft., without sliding the wheels and without the use of sand.

The street cars are mounted on four wheels and are not specially worthy of note. They are all of rather small size, adapted to the towns in which they operate. They have the usual street car wheels, with treads 2½ ins. wide and flanges ¾-

FIG. 5. HIGH-SPEED INTERURBAN ELECTRIC CAR, UNION TRACTION CO. OF INDIANA.
St. Louis Car Co., St. Louis, Mo., Builders.

in. high, so that at frogs and switches used by both the city and interurban cars, the former ride rather heavily, the small wheels dropping into the wide throat provided for the larger wheels of the latter cars. These street cars have motors of 50 to 75-HP., one on each axle. They are painted yellow and white, while the interurban cars are a dark green.

POWER PLANT.

The current for the entire system is generated at a power station in North Anderson, the plan and cross-section of which are shown in Fig. 7. The power house is 161 × 114 ft. inside, with an engine room 70 ft. wide, and boiler room 42 ft. wide. It is a brick and stone building, with steel columns enclosed in the walls and supporting steel roof trusses; on these trusses are closely spaced lines of purlins with book tile roofing between, the roof being covered with a tar and gravel composition. The boiler room has triangular roof trusses, designed to carry the weight of the coal bins suspended from the lower chords, and has a monitor roof in which runs the coal conveyor, above the bins. The engine room has a flat roof, with a slight pitch to the top chords of the trusses. The height in the boiler room is 22 ft. 6 ins. to the bottom of the coal bins and 35 ft. to the roof trusses; in the engine room there is a clear headway of 21 ft. to the crane and 30 ft. to the roof trusses. Piers in the brick walls of the engine room carry the plate girder runways for a 25-ton Pawling & Harnischfeger electric traveling crane which serves the entire floor area. A 10-ft. basement accommodates the coal crusher and coal and ash-handling machinery, pumps, condensers, etc. Separate from the building is a brick chimney 180 ft. high, with a 10-ft. flue. The mechanical and electrical engineers for the power plant and electrical equipment were Sargent & Lundy, of Chicago. The power house and chimney were built by Pulse & Co., of Lebanon, Ind.

In the boiler room are eight Babcock & Wilcox water-tube boilers of 400 HP. each, and there is space for another pair of boilers, but at present six boilers are sufficient to meet the demands. All these are fitted with the Babcock & Wilcox self-feeding chain grate, and over each boiler is a coal pocket, with a spout to the grate. Coal cars are delivered on a siding at one end of the building, and the coal is dumped into a hopper opening in the ground. The hopper leads to a cracker or crusher which reduces the coal to a 1½-in. size suitable for the grates, and from this the coal falls into a McCaslin continuous overlapping bucket conveyor and elevator, with malleable iron buckets. This conveyor carries the coal along the basement, up the opposite end of the building and back over the pockets or bins above the boilers, the coal being discharged into any bin as required. These bins have an aggregate capacity of 250 tons, while the average daily coal consumption of the plant is 60 to 70 tons.

Chutes conduct the ashes into chambers beneath the ashpits, which can hold the ashes for a run of 48 hours. These chambers have vertical iron doors opening above the side of the conveyor. At suitable times, when the conveyor is not handling coal, the doors are opened and the ashes are washed out with a stream of water from a hose, the ashes falling through a movable chute into the conveyor buckets, which carry them back over the coal bins and discharge them into a hopper or bin, from which they are loaded by gravity into wagons or railway cars for disposal. The coal and ash handling plant, including the coal crushing machine, was installed by the John A. Mead Mfg. Co., of New York. It has a capacity of 45 tons per hour, and requires about 6 HP. for its operation.

The water supply for the boilers is pumped from two deep wells in the basement to an elevated tank of 20,000 gallons capacity. It is very free from lime and causes but little scale in the boilers. The water for the condenser is obtained from a neighboring creek, through a 48-in. brick culvert.

There are three generating units, with space provided for a fourth unit. Each unit has a cross-compound Corliss engine, built by the Rice & Sargent Engine Co., of Providence R. I. These engines have cylinders 26 × 48 ins. and 50 × 48 ins. and are rated at 2,000 HP., with 140 lbs. steam pressure, 27 ins. of vacuum and running at 100 revolutions per minute. The connecting rods are 12 ft. long, c. to c. of bearings, and the crank pins are 8½ × 8½ ins. There are two eccentrics to each cylinder, and no wrist plate is used, the eccentric rods having extensions which operate the steam and exhaust valves respectively. The valves are of the cylindrical gridiron type. All working parts are entirely enclosed in a Russia iron housing, even including the piston rod, crosshead, connecting rod and crank disk; the object of this is partly for safety and partly to prevent any oil from being thrown on the floor. The engines have the Rites automatic governors and Blake condensers.

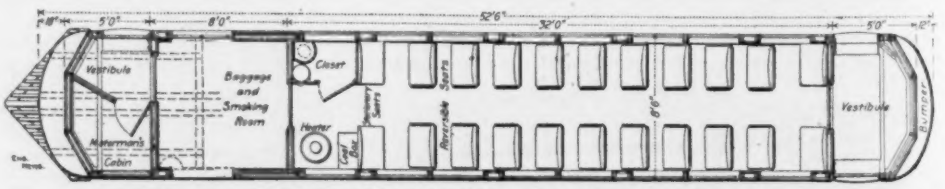


FIG. 6. PLAN OF ELECTRIC INTERURBAN CAR.

The engine shaft is 24 ins. diameter, with bearings 22 × 38 ins., and carries a 60-ton built-up flywheel, 18 ft. in diameter. On the shaft of each engine, and close against the flywheel, is a Westinghouse three-phase, alternating-current, 400-volt, 1,000-K-W. generator. A storage battery of 450-K-W. capacity (for use as an auxiliary or reserve), rotary converters, static transformers, and two direct-current 125-volt exciter units complete the electrical equipment of the station. One of the exciters is driven by a Ball steam engine and is used only when starting up the plant; the other is driven by an induction motor, and is used when the plant is running. The latter is the more economical in performance, owing to the greater fuel economy of the main engines. A gravity oiling system is used, supplied from elevated tanks on the wall of the engine room, the oil being collected, filtered and used over and over again.

The 400-volt alternating current is stepped up to 16,000 volts at the power house, and transmitted at this pressure on the high-tension lines to the substations, where it is stepped down to the 550 or 600-volt direct-current which is led to the feeders and trolley wire. For this there are 15 rotary converters of 250 K-W. each, three at the power house and the others at the eight substations, 10 to 35 miles distant. As a reserve and auxiliary there are nine storage batteries of 150 to 450 K-W. each, one at the power house (which is also the Anderson substation) and one at each of the outlying substations. In the engine room are two white marble switchboards; one is for alternating current for the high-tension transmission lines to the substations; the other is for the rotary converters and direct-current feeders for that section of the trolley line supplied directly from the power house. The plant is operated from 21 to 22 hours per day, and the entire plant is now generating power at a cost of 0.4 to 0.5 ct. per K-W.-hour, with coal at $1.40 per ton. This includes all wages, fuel oil, waste and repairs.

SUBSTATIONS.

There are eight substations, besides the rotary converters which form the Anderson substation at the power house. These are at Marion, Alexandria, Muncie, Fairmount, Elwood, Daleville, Ingalls and Lawrence, as shown on the map, Fig. 1. Each of the three first-named have two 250-K-W. rotary converters, one 16-K-W. Crocker-Wheeler booster, four 175-K-W. static transformers, and a storage battery of 264 cells, 168-K-W. capacity. Each of the other substations has one rotary converter, one 8-K-W. booster, and a storage battery of 264 cells, 84-K-W. capacity. All are equipped with static transformers. All of these substations are brick buildings, with roofs supported by I-beams, on which run 6-ton trolleys for handling the machinery. There is also a portable substation for use in case of any accident at a substation or in the event of a temporary increase in capacity being required at any substation. This is a double-truck car, 21 ft. 6 ins. long and 8 ft. 8 ins. wide, containing a 250-K-W. rotary converter, three 87.5-K-W. static transformers, and high and low tension switchboards. This car ordinarily stands on a sidetrack running into the power house.

TELEPHONE TRAIN DISPATCHING.

One of the specially interesting features of this railway is the operation of its interurban traffic by the telephone train-dispatching system. There is a complete printed schedule or working timetable showing the time each train is due at each town and each turnout, and the time at every meeting point is printed in heavy type. Each motorman and conductor carries a copy of this timetable. As long as a train is on time it is run by this schedule, but should it reach any turnout five minutes late, or reach a passing place and not meet the opposing train, the conductor calls up the train dispatcher (at Anderson) for orders. At each turnout the telephone wires are brought down one of the posts on each side and end in a hood within convenient reach from the window of the motorman's cab. A portable telephone is carried in the cab, and contact is made by a flexible cord, on the end of which is a short stick having spring contact pieces which fit over the connections in the hood. The conductor is thus in direct communication with the train dispatcher. The

telephone wires are also brought down the poles at half-mile intervals, so that in case of accident or any emergency along the line, the conductor can take down the portable telephone and carry it to the nearest pole having a connection. These connections are used also by work trains in getting orders at different points of the line wherever they may be working.

Train-orders are only used for special orders, when a train is not running on its schedule. A pad of printed blanks is carried in a holder on the portable telephone box, and the conductor fills in one of these as the dispatcher dictates; the dispatcher also states the time at which the order is given. The conductor repeats the order back to the dispatcher, and gives his initials, after which both he and the motorman sign the order. The train dispatcher also has his copy of the same order, so that in case of any accident resulting the orders may be compared. A train order of this kind will read as follows:

"Train No. ...., Motor No. ...., will pass Train No. ...., Motor No. ...., at Switch No. ..... Report at Switch No. ...., Time of Order .... Conductor ....."

All the trains are controlled from the dispatcher's office at Anderson. The dispatcher sits before a blackboard 6 ft. long, on which are marked straight lines representing the two main lines and the Elwood branch. The towns, substations, etc., are indicated; the miles are marked in red and the number of each switch in yellow. There are also holes at each switch, in which to insert plugs. In front of the board lies the train-sheet for the day, with a column for each train (headed by the name of the conductor and motorman) and a line for each switch. The conductors sign a book at the Anderson office and report by telephone on their arrival at and previous to their departure from terminal points, so that special orders, slow orders, or notices as to extras, etc., can be sent to them. The times at which these reports are made are entered on the train sheet, and are the only times entered as long as the trains are running on their schedule time. Should a train be late, however, and the conductor call up the dispatcher for orders, the time of receiving the call is entered, and if a new passing place is ordered a numbered plug is inserted in the hole representing the switch at that place, to remind the dispatcher that the train bearing that number is to report from that point. Only one train reports at passing points. The dispatcher has a receiver clamped to his head, and a transmitter suspended in front of his mouth, so that his hands are free to operate his plugs, fill in his train sheet, etc. The number of interurban cars in service each day is about 18; this includes six ordinary and two "limited" cars between Indianapolis and Muncie.

At one point in Anderson the city and interurban cars travel over the same single track for the length of six city blocks. To protect this an automatic block signal system is put in, operated by the trolley connections. As soon as a car enters one end of the block, it cuts off current from a section of the trolley wire at the other end, while a red light is also shown in a box on a pole at the other end.

There is a complete telephone service over the entire system, with wires independent of the dispatcher's wire, so that the head office is in touch with all parts of the line, as well as with officers who may be at different points on business.

TRAIN SERVICE AND FARES.

Trains run hourly each way between Indianapolis and Muncie (passing through Anderson) from 4.15 a. m. to 7.15 p. m., and then at 9.15 and 11.15 p. m. These make the trip in about 2 hours 40 minutes, stopping at various points. In addition to these, there are four "limited" trains each way, which stop only at Anderson, and make the trip in 2 hours. The fare is 65 cts. on the ordinary or 90 cts. on the "limited" trains. From Anderson there is an hourly service to Alexandria, Marion and Elwood, with "limited" trains every two hours, these latter trains, however, taking the place of regular trains instead of being additional trains as on the Indianapolis and Muncie lines. The minimum fare between any one stopping place and the next is 5 cts., and above this the fares are graduated according to distance. Six 5-ct. tickets are sold for 25 cts., but these are good only on the city lines. There are no round trip tickets. A fare on the interurban cars entitles the passengers to a transfer ticket for any of the city lines, except in Indianapolis, where the street railways are owned by a different company. The schedule of through fares is as follows:

	Fare—Ordinary, cts.	Fare—Limited, cts.
Indianapolis to Muncie	65	90
" to Marion	80	95
" to Elwood	70	85
" to Anderson	45	60
Anderson to Muncie	20	30
" to Alexandria	15	15
" to Elwood	25	25
" to Marion	35	No lim. train

The schedule speeds are 40 to 45 miles an hour, and speeds of 50 to 60 miles an hour are not infrequently attained. In the towns, of course, the cars run at the ordinary speeds of street cars. Accidents are rare; animals are occasionally run over, but very few people have been hurt, and very few collisions or derailments have occurred. The most serious collision was due to two cars running in the same direction entering a section from which the current had been cut off, and each motorman allowing his car to drift as far as its momentum would carry it. The heavy bumper beams prevent any telescoping of the cars, and the brake equipment and power has already been described.

In regard to the competition with steam railways, we may take as an example the Indianapolis and Muncie line, 56 miles, which parallels a main line of the Cleveland, Chicago, Cincinnati & St. Louis Ry., 53.7 miles. The steam railway has a service of six trains each way daily (but one of these leaves Indianapolis about 4 a. m.). Four of these six trains stop only at Anderson, while two make seven intermediate stops in the 53.7 miles. The fare, however, is $1.65 instead of 65 cts. (or 90 cts. on the fast electric trains), while the time is from 1 h. 25 mins. to 2 hours. The electric service also lands passengers at various parts of the towns and cities, and the interurban fare includes a transfer to any of the city lines (except in Indianapolis) as already noted. When the electric line was first opened the steam railway put on additional trains and made special rates in an endeavor to compete with it, but it soon found that it could not get the traffic and abandoned the competitive service and rates.

The traffic taken away from the steam railway, however, is but a small proportion of the total traffic of the electric railway, as the better service of the latter has increased the through traffic, while it has developed a considerable local traffic between the various towns, and between towns and the country districts served by the road crossing stops. Nearly all the towns and villages on the line have at least one factory or industry, and several of them are important manufacturing centers, so that the electric railway has not to rely only upon a rural or agricultural population.

Parcels and baggage are carried, a regular baggage check system being in force; the local transfer or express companies collect and deliver at the railway offices. No freight is handled as yet, but some freight cars have been ordered for light freight or package-freight service. Cars may be chartered for picnics or excursions.

For its running powers or trackage rights in Indianapolis, the Union Traction Co. pays to the Indianapolis Street Ry. Co., a fixed sum per annum for each car and a fixed sum for every passenger carried within the city limits. A terminal station for this and the other interurban lines entering the city has been proposed and is likely to be constructed at an early date by a company backed by the Indianapolis Street Ry. Co., as noted in our issue of Aug. 28.

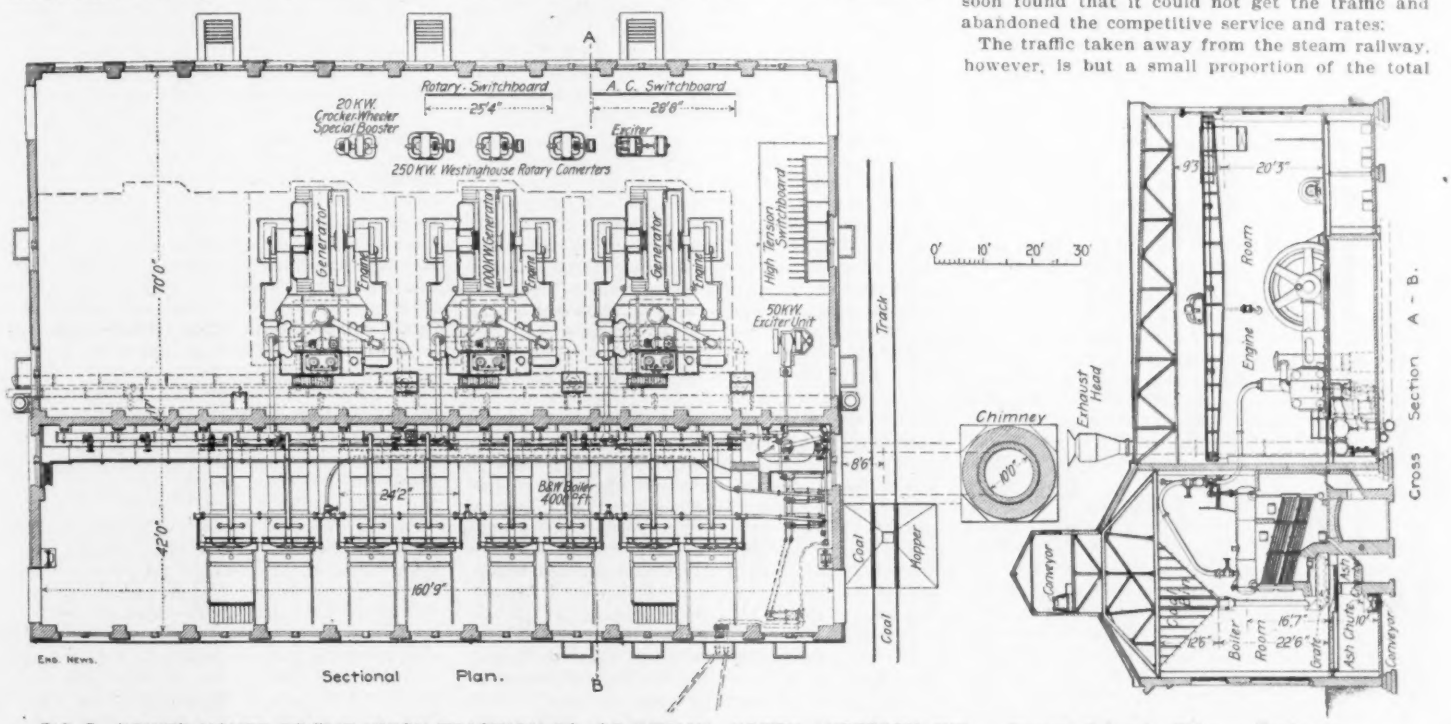


FIG. 7. POWER HOUSE OF THE UNION TRACTION CO. OF INDIANA, NORTH ANDERSON, IND. Sargent & Lundy, Chicago, Engineers.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

As those of our readers familiar with marine engineering matters are aware, the breakage of steamer screw shafts has been for some years one of the most puzzling of current engineering problems. Shafts have broken which by all the ordinary calculations had an ample margin of safety; and an increase in the size of shafts, while it has lessened the number of casualties, does not appear to have entirely removed the trouble.

The generally accepted theory of the cause of these failures has ascribed them to combined torsional and bending forces. The hull of the vessel to which the shaft is secured is far from being a rigid body. On the contrary, when subjected to the heavy stresses due to wave action it must be considerably distorted, and these distortions it is thought may be sufficient to throw the shaft out of line and add considerable bending stresses to the torsional stresses due to the action of the engines upon the screw. So far as this theory holds true, it will be seen that an increase in the diameter, and consequently the stiffness of the shafting, may make matters worse instead of better.

Another theory which has been put forth more recently to account for these shaft failures is that they are due to torsional vibrations of the shaft. The turning moment of the engine cranks upon the shaft is constantly varying, and in a heavy seaway, where the screw is alternately in and out of the water, the resistance at the other end of the shaft varies in still greater degree. Now the shaft, like every other solid body, is elastic. It yields under applied forces of torsion just as truly as a beam bends under an applied load; and just as a beam may be broken by a load applied with rythmic effect corresponding to its period of vibration, so a shaft may be broken by the torsional vibrations due to rhythmically applied forces, such as the crank effort of a marine engine.

An investigation of this theory has been made by the ship-building firm of Blohm & Voss, of Hamburg, Germany, and in the last quarterly number of the "Journal of the American Society of Naval Engineers" this investigation, which has been in progress for some three years, is described by the engineer who conducted it. To make the investigation, an electric chronograph arrangement was devised which gave an automatic record of the amount of twist which existed in a certain length of the shaft when the engines were running. These diagrams showed at once the existence of vibrations in the shaft, whose effect was to carry the turning moment or torsional force at a given point alternately above and below the figure representing the average. In the case of some engines tested it was found that the vibrations caused a momentary torsional force equal to nearly three times the average. Thus, when the average torsional stresses were 218.4 kg. per sq. cm., the maximum torsional stress was 600 kg., and the minimum was 166 kg. This latter figure gives really the best idea of what is going on in the shafting of an ocean steamer. These vibrations are so great that at some points in each revolution the torsional stress in the shafting is reversed and the propeller actually drags the engine along. To repeat the comparison of a beam in vibration, it is as if the beam were vibrating up and down under its load so as to throw the lower side into a tension at each vibration nearly as great as its normal compression under static load.

The practical application of this discovery is that to keep these vibrations within safe limits the speed of the engines must be regulated with reference to the natural period of vibration of the shaft. Thus, for example, when the natural rate of vibration of a certain shaft was found to be 257 per minute, engine speeds would be avoided, giving a number of revolutions equal to this number or its half, third, or quarter. Inasmuch as the speed of the engines is usually fixed by other considerations, the practical solution of the problem, when the number of revolutions is found to approach the natural rate of the shaft, is to change the latter by altering the shaft diameter.

A curious and unexpected outcome of these investigations was the development of a system of measuring the power developed by marine engines. From the torsional deflection of the shaft found by the electric chronograph, it became possible with the aid of the modulus of elasticity for torsion to determine the forces actually transmitted, and thence with a knowledge of the speed, the power also. Special determinations of the modulus of elasticity were made for the particular steel used in the shafts, and thus the "brake horse-power" of the engines was determined. It is of interest to note that the efficiency of the engines was found by this method to be from 88 to 93%. The author thinks the method accurate within from 0.5 to 1%, or about the degree of accuracy that might be expected from indicator diagrams.

For nearly four years past in this country, demand has been in advance of supply in many lines of manufacture. Particularly has this been the case in the iron and steel trade. Notwithstanding the huge output of modern mills, and notwithstanding the constant addition of new plants and the operation of old ones which have stood idle in dull times, there has been a market for all the iron and steel that could be produced, and during the last year consumers have purchased large quantities of iron and steel in foreign countries to meet their requirements.

Of course, every intelligent and conservative observer has realized that this condition of things could not last. Expansion at the rate of the past four years could not, in the nature of things, continue indefinitely. The fact is that a large part of the market for iron and steel has been furnished by this very expansion. Stop the building of new mills and factories, and the balance between demand and supply will be ot once upset. Prices will fall, and with them will go the stimulus to further increase in productive capacity.

It would be interesting to point out in detail the causes which have contributed to the phenomenal industrial activity of the past four years, and to show how these same causes are now working toward a reaction. Our present purpose, however, is only to show something of the extent to which productive capacity has already outrun demand in some branches of the iron and steel trade, as indications of what the future has in store.

The most prominent branches in which overproduction is now a fact are tin plates and sheets. "The Iron Trade Review," in an editorial a few weeks ago, gave an interesting summary of these trades, which we reprint as follows:

	Gross tons—Sheets.	Tin plates.
Capacity of independent mills,*	500,000	200,000
Capacity of U.S. Steel Corporation mills	470,000	525,000
Total	970,000	725,000
Total production of 1901	500,000	400,000

*Built and building.

These figures are indeed startling. They show that even if the future rate of consumption were equal to that in the prosperous year of 1901, there are mills enough to supply nearly double this amount of sheets, and over 50% in excess of the requirements for tin plate. It goes without saying that this situation, with the large number of mills outside the steel trust, means a reduction of prices till profits reach a vanishing point. In fact, a cut in prices of 40 cts. a box has recently been made by the American Tin Plate Co.

While these are the branches in which the greatest surplus capacity has accumulated, much the same process is taking place in the wire and pipe trade, in bar iron, and to less extent in some other minor fields, and lower prices are confidently looked for as a result.

It is true that these are all departments whose total tonnage is not great; yet ultimately it is bound to have its effect on the general market for other lines, particularly in connection with the fact that capacity in these lines is also increasing at a phenomenal rate. The high prices of lumber and the activity in the building trade have produced a demand for structural steel which is likely to maintain prices there after they have fallen in other branches. Even here, however, the prospect of lower prices, together with a general slackening of industry, is pretty certain to cause a marked reduction in demand in the not far distant future.

The German law against unfair competition in business, described in a recent consular report, is worth serious attention by all interested in the promotion of sound business methods. In the United States there are practically no restraints upon the unscrupulous manufacturer or dealer who resorts to extreme means to get the better of a competitor. We except, of course, the ordinary criminal laws and the law of libel; but there is a long list of things which can be done by an oversharp man to defeat a rival and defraud the public for which the law provides practically no remedy. The list of offenses covered by the German law is given as follows in the Consular Report referred to:

1. Fraudulent advertising, i. e., false declarations concerning methods of production, make-up or prices of wares; source of supply; reason for selling; possession or ownership of trade-marks. In the above cases, every business man or group of business men has the right to bring suit against the offending party, calling for the suppression of the above practices, also for damages. A fine not exceeding 1,500 marks ($357) can be imposed; repetition of such an offense is punishable with imprisonment not exceeding six months.
2. Detraction of a competitor, i. e., spreading false reports concerning the trade of another, his person, the manager of his business, or his wares. Offenses of this nature are punishable with a fine not exceeding 1,500 marks ($357), or imprisonment not exceeding one year.
3. Misusing another's name in such a way that an unfair advantage is gained. Offending parties must pay damages and are compelled to discontinue such practices.
4. Disclosing business secrets during time of employment. A fine not exceeding 3,000 marks ($714), or imprisonment not exceeding one year can be imposed, and in addition, judgment of damages sustained. Any competitor using information gained in this way, as well as any third person disclosing such information to him, is liable to a similar punishment.
5. Deception as to the quality of goods. The Federal Diet has been empowered to prescribe that certain articles are to be sold at retail only in certain quantities, lengths, according to certain numbers, etc., or with declarations as to number, weight, etc. The punishment for every infringement shall not exceed 150 marks ($35.70.)

It may be said that a party injured by such practices as those above enumerated can find de-

dress in this country by an action in the civil courts; but this remedy is more apparent than real. Courts and juries are apt to look on any such case as merely a private dispute between rivals, and the case must be strong indeed where really compensatory damages can be obtained. Moreover, the absence of law upon the subject tends to a looseness of ideas and of conduct among men who would not intentionally break a law or use unfair means to defeat a competitor. There is a too-prevalent idea that "business is business," and that all is fair in the warfare of trade. Probably it would be quite possible to find business men of good reputation who would contend that the list of practices made criminal by the German law are perfectly fair and honorable.

Not the least of the benefits of such a law is that it serves as a guide to men of this stamp and establishes a standard of honesty and fair dealing.

THE LABOR PROBLEM IN THE ANTHRACITE COAL MINES.

Now that President John Mitchell, of the United Mine Workers, has filed with the "Strike Commission" a formal enumeration of the demands made by the recently striking miners, we are enabled to judge the merits of the miners' claims.

Briefly, the miners' demands are four in number:

(1) An 8-hour day with 10-hour pay.

(2) An increase of 20% in price of piece or contract work.

(3) A minimum rate of 60 cts. for a "legal ton" of 2,240 lbs.

(4) Recognition of the United Mine Workers of America as a union.

Obviously, demands (1) and (2) were intended to be equivalent, but the miners have erred if such was their intention, for a 20% reduction in time is equivalent to a 25% increase, and not 20%.

The real issue is said by the miners to be the recognition of their union, but when we simmer it all down that is not their ultimate aim, for a union is manifestly organized primarily to secure higher wages, if not now, then at some time in the near future.

The issue, so far as the operators and the public are concerned, is the one of wages, and in the end that is the issue also so far as the miners themselves are concerned, hence we shall give to it most of our attention in what follows.

The miner has claimed that he is underpaid, that he receives not much more than $1 a day upon which he and his family cannot live according to the American standard of living. The operators have replied that the miner receives $2 a day, which is all that they can afford to pay with present selling prices of coal. As a matter of fact both sides have stated a partial truth, but each has neglected to state the whole truth, which is quite characteristic of contestants in every debate.

The miner, when speaking of "daily wages," means the quotient found by dividing his annual earnings by the working days in a year—not by the days actually worked.

The operator means by "daily wages" the rate paid for 10 hours work. These two kinds of "daily wages" are decidedly different, for while there are some 300 working days in a year, the anthracite coal workers have averaged only 189 days actually worked each year for the past 25 years. The miners, moreover, obscure the issue by including boys in their list of "miners," whereas the operators, quite as unfairly, class only those as "miners" who actually break down the coal.

	No. engaged.	Per ct. of grand total.	Average wages per 10 hrs.
Miners	36,000	25.5	$2.50
Miners' helpers	24,000	17.0	2.25
Timber, track, pump and brattice men and Co.'s laborers	12,500	8.9	1.75
Drivers (mostly large boys).	10,000	7.1	1.35
Bosses	1,300	0.9	13.00*
Other inside men	6,200	4.4	1.90
Total, inside men and boys	90,000		
Breaker boys (outside)	16,000	11.4	0.65
Company laborers (outside)	8,000	6.4	1.50
Mechanics (outside)	2,000	1.4	2.25
Engineers (outside)	1,200	0.8	2.25
Firemen (outside)	3,300	2.3	1.65
Bosses (outside)	800	0.6	13.00*
Other outside men and boys.	18,700	13.3	1.50
Total, outside men & boys	50,000		
Grand total	140,000	100.0	$1.85

*$13.00 per week.

A member of our editorial staff some years ago worked (all one summer) with miners underground in an anthracite mine near Shenandoah, and has recently visited the Northern anthracite district. The rates of wages given in the table at the bottom of the preceding column may be relied upon as nearly enough correct for all practical purposes.

For the last eight years 140,000 has been the approximate total number of workers in the anthracite fields. The increase of output of the miners which has taken place during that time has been brought about by increased efficiency of machines and methods used in mining and cleaning the coal:

Referring to the last item of the last column, we see that each of the 140,000 men and boys engaged in producing coal is receiving $1.85 for every 10-hour day worked. This result is obtained by multiplying the items in the second column called per cent. by the rate of wages in the third column, adding the respective products thus obtained for each class of workers and dividing by 100. This manifestly gives us a true average rate of wages per 10-hour day for all workers engaged.

As above stated, the workers have averaged only 189 days (10-hour) per annum for the last 25 years, hence at present rates of wages (which were raised 10% after the strike in 1900), each worker would receive $189 \times \$1.85 = \$349.65$ per annum. Dividing the annual earnings by 300, the available working days in a year, we have $1.16 per day, which we see is not far from what the miners have claimed as being the average "daily wage;" while we also see that the operators in giving $2 as the average "daily wage," according to their way of reckoning, have not been far from the $1.85 above given, which is probably very near the truth. It may also be said in favor of the operators that about 20% of the workers are young boys who should not rightly be classed with the men in computing average wages.

It is evident that the kernel in this controversy is the discrepancy between daily wages and annual wages. There is not the slightest doubt that if the mine workers could receive $1.85 a day for 300 days instead of 189 each year they would be perfectly satisfied with their lot. Indeed, their strike for an 8-hour day is practically a strike for 25% more working days per annum; for if it now requires, say, 200 days of 10 hours each to supply the demand for anthracite, it will require 250 days of 8 hours each if the miners win this contention.

If, however, we read President Mitchell's reasons for their demands, we read the reasons of an advocate, not of an impartial judge; for he claims that an 8-hour day is equally as efficient as a 10-hour day. But if he really believes this to be so, why strike for an 8-hour day at all? If in 8 hours a man can produce as much as in 10 hours, then surely there will be no more days worked in a year after the strike than before it, and since no increase in daily wages is asked for those working by the day, manifestly the annual earnings of each worker will not be increased if the 8-hour day is granted. On the other hand, it would seem to most people that the miners, who for the past 25 years have averaged 6 hours and 18 minutes worked each working day of the year, have little to need in the way of more leisure for "mental improvement" or "recreation."

We can hardly believe that Mr. Mitchell or his followers really regard an 8-hour day as being as productive as a 10-hour day, and we may positively state that in coal mining an 8-hour day cannot possibly be as "efficient." Therefore, the miners are really contending for 25% more days actually worked per annum when they demand an 8-hour day, but the question arises whether their way of increasing the number of days annually worked is really best for them and for all concerned.

Two years ago a 10% increase in wages was given the miners after a short strike. Now a further increase of 25% is demanded. The recent long period of idleness in the anthracite region has undoubtedly led many factories and steam-heating plants to adopt the use of soft coal and smoke-consuming devices which will materially decrease the demand for anthracite in the future. If on top of this the demand is further decreased by adding 35% to the labor cost of anthracite production inside of two years, we may confidently look for a still greater soft coal inroad upon the anthracite markets. In the end, therefore, the effect would be to still have more workers in the anthracite fields than are actually needed, which is just what has caused the recent strike and other strikes in the past.

The time will very likely come when workers in many trades throughout the country will have the 8-hour day, but so long as the great majority of men, and especially of soft coal miners, still work 10 hours, it is suicidal to ask for the 8-hour day in the anthracite mines.

The operators and the miners alike will concede that there are too many workers in the anthracite fields, and that 100,000 workers could do the work of the 140,000 now engaged provided steady work were possible. It is not unlikely, however, that both will maintain that the very nature of coal mining makes uniform production out of the question. Let us therefore review the conditions which in the past have led to an excess in the supply of workers in the coal fields.

In the early days, when coal was transported by canals which were frozen up and closed during the winter, the actual mining had to be done in the warm weather months when the canals were open.

Later, when railroads displaced canals, conditions were reversed and most coal was mined during the cold weather.

During both periods, therefore, there have been seasons of activity followed by seasons of dullness in coal mining. Working under such conditions manifestly requires a greater number of workers during the busy season to supply the demand, and it has been neither the fault of the miners nor of the mine owners that the supply of men exceeded the demand at times. Thus we come to see that we must look into the conditions governing coal production if we are to find the real solution of the labor problem.

When the mining of the early days was done mostly in the warm months, and the coal immediately transported by canal to market, the coal must have been stored in the retailers' stock yards or in the bins of individual consumers, to a far greater extent than is now the case. If we could go back to this earlier practice, we would in fact find the best solution of the present problem, for the railroads now enable the mines to ship a uniform amount of coal the year round—a condition impossible with canals.

The mine operators, by coöperating with the retailers, can evidently do now exactly what was formerly done, that is, supply storage yards to hold the excess of coal mined in the summer.

Without going into details, it may be added that the interest on the capital locked up in stored coal would not add more than 3 cts. per ton to the cost of production, a sum which consumers would gladly pay several times over for insurance against strikes such as the last; moreover, this 3 cts. per ton would be largely offset by decreased cost of transporting because of fewer cars and engines required to handle a uniform production.

We see that from the earliest times down to the present lack of storage facilities brought about by the desire to save interest charges on stored coal have made necessary an excess of workers, and correspondingly low annual earnings for each worker, although day wages were high. This very existence of high daily wages has tended to attract more laborers to the mining field; for laborers are usually so short-sighted that when they see a chance to earn $2 or $2.50 a day, they seldom stop to ask how many days a year they can actually work.

Then there are a number of days lost each year by flooding of collieries and by freezing of the water supply of breakers, both of which are largely preventable. Shut-downs for repairs to plant are common, but generally are made to conceal the real purpose of limiting production to the demand at the time.

Miners lose about 1¼ days each per annum due

to accidents to themselves—a much smaller number than some would have us believe. They also lose some days taken as religious holidays, as well as the legal holidays; and they often take "a day off for a good time." There undoubtedly are many lazy and many intemperate miners, but probably no more in coal mines than in other walks of life. The miner knows by past experience that he is certain to be out of work for at least one-third of the working year, and, being no fool, he often takes his days off "all in a bunch" to suit his own whims and not at a time to suit his bosses. We think this explains much seeming laziness.

Making all due allowance for time necessarily lost from holidays, from accidents to men and plant, from incurable laziness of a few men, from imperfect coördination of mines and railroads (which now is a very small factor since the railroads own most of the mines), we believe that the coal breakers can actually be run at least five days a week throughout the year, or 260 days per annum.

To this end, the force of workers ought to be reduced to about 110,000; that is, 30,000 employees must be dropped from the rolls.

There are not less than 20,000 boys in the breakers and in the mines under 15 years of age, and a great but unknown number of these are under the legal 12-year limit. In justice to these children themselves, to the men whom they displace, and to society at large they should be dropped from the pay rolls of the mines.

To make effective any decision of the Strike Commission in this regard, they should establish not an age limit of, say, 15 years, but a weight and height limit corresponding to what physicians recommend as a fair weight and height for a 15-year-old boy. This may be unfair to a few undersized boys, but laws and rules can never be made to fit every exception, and to completely exclude individual injustice in occasional instances. Then, if a board of physicians were to make visits to the mines at intervals to measure and weigh the boys at work, it would be possible to fix the burden of guilt where it belongs, if children under the limit are permitted to work.

The result of excluding these children will be to increase the number of men employed each working day, and therefore to increase the number of days worked in the year. It will also add about 8% to the annual wages of all the workers left (110,000), which, by the way, is only one-third what the miners now demand.

But to still further increase the annual wages of the men, at least 10,000 more workers must be dropped from the rolls.

This may seem unjust to these few, but there is work in abundance throughout the country, and none need suffer by this act, particularly since miners can work at almost any other kind of manual labor.

To remove that fatal fascination of high daily wages, and at the same time to force the operators to supply coal storage facilities in order that work for the men will be steady, it is imperative that the method of payment be changed from the present daily wage to a weekly wage system. Assuming the average daily wage of men to be $2 now for 190 days, the annual earnings are $380. In place of this a weekly (say 55 hours) wage of between $9 and $10 should be paid every week in the year; the men being docked only for hours lost through their own fault, no time being deducted for shut-downs for repairs, etc. A system similar to this is already in successful operation in some of the Lake Superior copper mines, for example, and it is satisfactory elsewhere.

Further than this it seems unnecessary to go in outlining a simple and practical method of effectually removing the conditions that for 40 years have made coal mining a seeming feast for the mine workers, where in reality it has been for much of that time a famine.

LETTERS TO THE EDITOR.

A Correction in the Scow-Measurement Formula.

Sir: In your issue of Oct. 23, in answer to an inquiry regarding the measurement of a loaded deck scow by means of gages, you give a formula for computing the average gaging. If *n* in your formula represents the total number of gages, should not the denominator be *n* — 1 instead of *n*? In the summation of "averages" the number of terms is one less than the number of gages, therefore to get the "average gaging" the divisor should be *n* — 1 and not *n*. Respectfully,

Carl Bannister.

U. S. Engineer Office, Erie, Pa., Nov. 8, 1902.

[In the formula as printed the denominator should have been n — 1, instead of n. Mr. Lion, in our issue of Nov. 6, uses the same formula except that both numerator and denominator have been multiplied by 2, giving $\frac{a + 2\Sigma m + b}{2(n-1)}$. —Ed.]

Requirements for Admission to the Naval Civil Engineer Corps.

Sir: The requirements for applicants desiring to take the competitive examination for entrance to the Naval Civil Engineer Corps have from time to time been published in your news columns. One of the essentials is that a man must hold the degree of civil engineer, and the Navy Department has ruled that candidates holding other degrees than that of civil engineer are ineligible for examination. The question whether this is a wise restriction will best be answered by enumerating some of the most important duties of a naval civil engineer.

These officers are charged with the design, construction and maintenance of all dry-docks, sewers, pavements, water-supply systems, railroads and rolling stock, all buildings and everything that might properly be termed civil engineering work. In addition this department is charged with the design, construction and maintenance of all electric subways, telephone and telegraph lines, electric power stations and equipments and in some cases electric trolley lines, as well as the supervision of all machinery and equipment of the machine shops, joinery shops, etc. By a perusal of the expenditure account one finds that the major part of the annual appropriations are spent on strictly mechanical and architectural engineering works. Why then bar out candidates who hold mechanical, electrical or architectural engineer's degrees? The absurdity of the requirements is emphasized when attention is called to the fact that the holder of a degree is required to answer simple questions on elementary subjects taught in the high schools. Why then require a candidate to hold any degree?

The writer is convinced that if the Navy Department would waive the requirement of degrees and permit all candidates who filled the necessary physical and age requirements to enter the examinations, making proper allowance for education, experience and training the same as is done by the Civil Service Commission, that their field to select from would be materially enlarged to the benefit of the service. Very truly yours,

S. F. J.

New York, Nov. 8, 1902.

A Unit of Quantity of Electricity for Use in Electrochemical Calculations.

Sir: A paper under the above title was presented by the writer before the American Electrochemical Society at its convention at Niagara Falls, Sept. 15 to 18, 1902. (See report of this convention, containing an abstract of the paper referred to, in our issue of Sept. 25, 1902.—Ed.) I have recently revised the calculations upon which the paper was based and in the following memorandum I give the results in their corrected form. You will notice that the agreement is even closer than stated in my paper above mentioned. I especially wish to present this memorandum since of three published abstracts of the paper which I have seen so far, two contained radical errors through wrongly quoting from the paper; the third one, the abstract which appeared in your journal, was almost correct. Knowing how persistently an error clings after it has once crept into scientific literature, I wish to put on record the correct figures as contained in the following memorandum:

If the atomic weight of hydrogen be taken as one, and the calculation is based on Dr. Edward W. Morley's determination of the weight of a liter or cubic decimeter of hydrogen, .089873 ± .0000027 grams, as given in Dr. Morley's paper on "The Atomic Weights of Hydrogen and Oxygen," in the "Smithsonian Contributions to Knowledge" for 1896, we must then attribute to silver an atomic weight of 107.1. Lord Rayleigh's determination of the electrochemical equivalent of silver is .001118 grams per coulomb. This would make the electrochemical equivalent of hydrogen .00001043786. Under these premises the "kilocrith col," or 100 international amperes for one sidereal day, liberates 1.00071 cubic meters of hydrogen under standard conditions of pressure and temperature.

The meter is not exactly one ten-millionth part of the quadrant of the earth from the pole to the equator. The most reliable figure for the distance from the pole to the equator is the determination made by Clarke in 1880, based upon all the arcs of the earth that had been measured up to that time. He found the distance from the pole to the equator to be 10,001,868 meters. Were one to correct the length of the meter in the light of this more reliable figure, the cubic meter would then become a little larger, and the 100-ampere current would then give 1.00015 cubic meters of hydrogen at 0° C. at the pressure of the atmosphere at sea level and 45° latitude, in one sidereal day. The sidereal day is 86,164.091 mean solar seconds, and measures the true revolution of the earth on its axis. This agreement is so close that it is well within the limits of error of the determinations of the various constants, and it naturally raises the very important question as to whether the agreement is absolute or not. Taken in connection with the law of Avogadro and the valencies of the elements, this agreement reaches to every element in chemistry. Hence, if this connecting link could be proven fundamental, the periodic law, the law of gravitation, and Coulomb's law of attraction between electrically-charged bodies, could all probably be brought within the scope of some broader generalization. Yours truly,

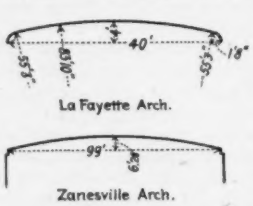
Alfred H. Cowles.

361 The Arcade, Cleveland, O., Oct. 28, 1902.

The Flattest Concrete-Steel Arch in the World.

Sir: In your issue of Oct. 30, the Osborn Engineering Co. takes exception to certain statements made in one of our leaflets regarding the "flattest elliptical arch bridge in the world." The leaflet in question was written with a full understanding of all the structures mentioned by your correspondent, including the Zanesville bridge, and we think a few words of explanation will show that we have done no violence to reliable statistics, and that your correspondent misinterprets our words.

We show herewith a drawing (to the same span) of the curves of the Lafayette arch, and of the flattest arch of the Zanesville spans. In claiming that the Lafayette arch is the flattest elliptical arch bridge in the world, we have used the word elliptical in the popular sense, meaning of the form of a semi-ellipse. Our leaflet clearly shows that the arch is five-centered, so that it is plain that we were using the word elliptical in this sense. The term basket-handle would more properly describe the curve, but obviously that term would not answer the purpose of a circular for non-technical readers.



The Zanesville arches of less than one in ten rise are not elliptical arches in any ordinary sense of the word. They are, more properly speaking, of the class of arches known as catenarian, approximating more nearly the segment of a circle than a semi-ellipse. The 99-ft. Zanesville span is so nearly the segment of a circle that it is impossible to detect the difference on a drawing to the scale we have assumed. Mr. Landor, the designing engineer for the American Bridge Co., who were the engineers and contractors for the Zanesville bridge, has made the following statement, Eng. News, March 27, 1902:

> With a view of fixing maximum waterway, elliptical contours were decided upon, but after examination it was found that only sections of semi-ellipses could be used in order not to curtail what we may perhaps term the effective depth or spring of the arch.

The curve of the Lafayette arch is vertical at the springings, that of the Zanesville arch is nearly horizontal. In the former a large part of the rise is ineffective, being consumed by the sharp curvature at the abutments, for the sake of appearance. It is obviously unfair to compare for flatness two such arches, and we are at a loss to understand why the Osborn Engineering Co. did not in their correspondence call attention to this difference, of which they were fully informed.

Finally, if we are to be held to a mathematical reading of our leaflet, we admit that we are perhaps at fault, although there is the redeeming feature, that while the Zanesville arch was designed as an arc of an ellipse, it is no longer such, having settled away from the true curve. Ordinarily when the term circular arch is used a complete semicircle is meant; when less than a semicircle is referred to, it is called segmental circular. By analogy, we think a semi-elliptical arch may be called elliptical, while a section of an ellipse should be called segmental elliptical. The other arches mentioned by your correspondent are not elliptical in any sense of the word.

We have since erected another bridge of 40-ft. span at Lafayette, with 4-ft. rise, in which the radius at the crown is 123 ft., or over three times the span, the only case on record, we believe, for arch bridges. In both of these bridges the arches rose free from the forms within four days after erection, and the centers were removed five days after placing the concrete of the arch ribs.

Very truly yours, The National Bridge Co.
Daniel B. Luten, Pres.

Indianapolis, Ind., Nov. 3, 1902.

Engineers, Contractors and Specifications.

Sir: I have read with much interest the several articles on this subject which have appeared in Engineering News during the past few weeks. I agree with you, on the whole, in your editorial remarks, and with those of Mr. Schermerhorn in your issue of Oct. 9.

There are a few points, however, to which I would like to call attention. It is pretty generally held by the courts that no provision in a contract can oust the courts of jurisdiction. The provisions making the engineer the sole judge of disputed points are held valid, with the reservation that the engineer is to exercise his judgment in good faith, and not in an arbitrary or oppressive manner. Of course, the burden rests upon the contractor to prove that these conditions are not fulfilled. The most intelligent jurists recognize the fact that when a man lets the contract for a building, for example, he wants a building and not a lawsuit; that questions frequently arise that must be decided on the spot by somebody, if any work is to be accomplished; and that they can be far better decided by the architect or engineer who is familiar with all the circumstances than by any court or jury, especially as they are usually technical questions. Courts usually favor settling disputes by arbitration, and if provision for arbitration is made in the contract it will almost always be sustained in the absence of fraud—and the complainant must prove the fraud.

A contractor on government work is more worried by hair-splitters and cranks than perhaps any other. One reason for this is that all government officials are hedged about by laws, rules and regulations; and there are so many grades of officers, many of whom seem to be principally concerned with trying to find a pretext for "calling down" some of their subordinates, that they have very little opportunity to use their common sense. These laws are intended primarily to protect the public against the dishonesty of contractors and officials, but the principal effect of many of them is to make everything cost far more to the government than to anybody else.

The clause in the specifications for the Charleston drydock giving the engineer full control over the work seems to me rather meaningless. If it is to be construed literally it establishes the relation of master and servant between the engineer and the contractor, and relieves the contractor of all responsibility for accidents and for the success of the work; but the whole tenor of the specifications negatives that interpretation. In fact, the law is probably such that the engineer is not at liberty to assume that relation.

The responsibility of a contractor for the success of other people's plans is a complicated question and depends much upon circumstances. The courts would probably hold that if the failure were due to some mistake in the plans, the contractor could reasonably be considered to have noticed it, and having failed to call the engineer's attention to it (especially if it could be shown that he did notice it), would be held responsible for the failure, specifications to the contrary notwithstanding. For example, if an engineer should design a steam boiler and neglected to call for a safety valve, it would be reasonable to suppose that the boiler maker would notice the omission, and should be held responsible; but if he called the engineer's attention to the omission, and the engineer decided that the valve was not necessary, the contractor would be relieved of the responsibility. A similar view would probably be taken of any mistake in the plans, whether vital or not, whatever the contract might say or omit to say, provided always that it contained no provision expressly relieving the contractor of all responsibility for them.

As to the provision in a contract that the contractor shall prepare his own working drawings and submit them to the engineer for approval, that is the almost universal custom; and I never heard of a contractor objecting to it. Contract drawings are seldom prepared in such shape as to be available as working drawings. On many kinds of work the contractor prefers to make his own, and it is only business-like to submit them to the engineer for approval, and his approval may be absolute or limited.

The hair-splitting engineer is an evil that is very burdensome to the contractor, sometimes to others also, and often very difficult to eliminate. An appeal to his superiors often has very unsatisfactory results, still more so an appeal to the courts. He sometimes improves with age, and sometimes grows worse; sometimes he can be bullied, sometimes deceived; sometimes, alas, he has to be bribed. When it becomes known to his superiors that the better class of contractors refuse to bid on his work, or increase their prices on account of his presence, the effect is good.

The rejection of incompetent bidders is another very difficult question. The courts will usually uphold an official in rejecting them provided he does not abuse his powers; and, as in previous cases, the complainant must prove the abuse. In the case of a private owner the awarding officer is responsible solely to his superiors and the courts can seldom intervene. The case is different with public corporations. There the officer is responsible to the law first and to his superiors or constituents afterward. An awarding officer hates to reject the lowest bid, if the bidder has complied with the law in all respects, especially if the job is of considerable magnitude. If he does the papers and others raise a howl about favoritism. A bidder with political influence can usually furnish personal bonds in any desired amount, and if a bidder has good financial backing a security company will usually go on his bond irrespective of his dishonesty or incompetence.

The city engineer often has a hard time dealing with contractors who have political influence, and it is not surprising if he sometimes comes out second best in the fight. If he is honest and competent he usually has public opinion and law on his side; in fact, the laws are framed specially to protect him. He also has the comforting knowledge that lawsuits cost him nothing and his employers but little—provided they win—and that juries are usually prejudiced in his favor unless the jury is packed. On the other hand the contractor is protected against oppression to a large extent by the public nature of his work. If the city engineer is a crank it soon becomes known to all the contractors. Their united political influence is great, and they can usually get rid of him.

One of the worst misfortunes that is liable to befall a city contractor is the enmity of the ruling political organization. They can make life a burden to him in numerous ways and they seldom hesitate to do so.

I think your contention that it is good business policy for the owner to assume all reasonable risks on a contract is perfectly correct and I think business men are rapidly coming to see it in that light. There is one risk especially which I think it is very bad business policy to place on the contractor; that is, the risk of getting his money promptly when his work is done.

The engineer has a great deal of power, but, like other powerful men, the courts will hold him strictly responsible for any abuse of his powers. Is it not possible that the same thing is true of financiers and trust magnates?

Very truly yours, Willis Whited.

286 Main St., Sta. B., Pittsburg, Pa., Nov. 4, 1902.

[One of the worst features of laws regulating the award of public works contracts is the qualification of the term "lowest bidder" by using the word "responsible," without defining the meaning of the word "responsible." The "lowest bidder" should, of course, be responsible, that is, he should have experience, capital and common honesty; but since the law is primarily designed to prevent favoritism in making awards, the awarding board should not have it left entirely to its own discretion to determine what constitutes "responsibility." Where the awarding officer is thus given a quasi-judicial power, the courts require such officer to give no reasons for his decisions, leaving the road open to a favoritism from which there is no escape, so long as the word "responsible" remains undefined.—Ed.]

Notes and Queries.

G. E. S., Yonkers, N. Y., writes:

Your editorial on the "Renaissance of the Sailing Vessel" is excellent. I have doubts, though, about the auxiliary steam power in this case. You must be able to hoist the screw out of water if you expect speed under sail, and I think you would get neither a good steamer nor sailing craft.

We should not consider it necessary to hoist the screw out of water and do not know of its being done where auxiliary power is applied to sailing vessels. Simply connect the screw shaft to the engine shaft by a clutch coupling and let the screw run free when the engine is not in use, and the vessel is under sail. This should absorb very little power.

THE LABOR COST OF COAL PRODUCTION.

The volume of mineral resources of the United States for 1901 contains some valuable statistics relative to the cost of coal mining, which is best shown by tabulation:

BITUMINOUS.

Year.	Men.	Days worked.	Short tons per man, day.	Total tons mined.	Price per ton.
1890.....	192,204	226	2.56	111,302,322	$0.99
1895.....	239,962	194	2.90	135,118,193	0.86
1900.....	304,375	234	2.98	212,314,912	1.04
1901.....	340,235	225	2.94	225,826,849	1.05
ANTHRACITE.					
1890.....	126,000	200	1.85	46,468,641	1.43
1895.....	142,917	196	2.07	57,999,337	1.41
1900.....	144,206	166	2.40	57,367,915	1.49
1901.....	145,309	196	2.36	67,471,097	1.67

It is noteworthy that while in eleven years the number of men engaged in mining bituminous coal has increased 77%, the increase in anthracite miners has been only 15%. In the same time the efficiency of each man as a coal producer has increased nearly 13% in bituminous mining, and nearly 28% in anthracite mining.

This increased efficiency of miners, especially in anthracite mining, is due in greatest measure to improved mechanical means of cutting coal, and of handling it.

The figures appear to justify the claims of the striking anthracite miners in their recent strike, that the number of days actually worked per annum in a large measure compensates for the apparently high wages received. Certainly 190 days a year out of a possible 300 (Sunday and holidays deducted from 365), does not speak well for the management; and we cannot but think that money expended in furnishing greater storage facilities would have paid the mine operators well, in view of the fact that a smaller number of men would have been steadily employed with nearly 50% added annual income per man. We are convinced, indeed, that the mine owners could have prevented the recent disastrous strike had they followed this plan of giving steadier employment to the men by providing additional storage facilities for coal produced in the summer.

It is noteworthy in this connection that the average days worked per annum for the four years above given has been 190 for the anthracite miners, as compared with 220 for the bituminous miners, a difference of 30 days or more than 15% in favor of the bituminuous miners, who at least are fairly contented with their lot.

Is it not pertinent for the Arbitration Commission, appointed to consider the anthracite miners' grievances, to ask the mine operators why they have not taken steps to keep their men more steadily employed?

It has long seemed to us a question of vital importance to the body politic—this question of how to avoid the present great waste of energy resulting from the idleness of mine, factory and farm laborers so many days each year. Here, for the first time, is presented the opportunity of doing a great good, not only to the miners, but to every branch of industry in the country, if the Arbitration Commission will avail itself of the chance presented.

Statistics often seem dry enough to the unthinking, but we find in the above still further food for thought. We see that whatever the ills of trades unionism in England, where the unions have arbitrarily restricted the output of each man, American unions have shown their wisdom by adopting no such suicidal practice, as an increased productiveness of the miners shows. Whether it is because of their wider reading and deeper thinking or not, certain it is that the leaders of the American miners' unions have acted wisely and in the best interest of the men in not fighting improved labor-saving devices for mining and handling coal.

ABSTRACTS OF REPORTS AT THE ANNUAL MEETING OF THE RAILWAY SIGNALING CLUB.*

COMPENSATION AND CRANK MOTION.

We recommend that the full stroke in a pipe line should come direct from the lever; and in case it should be necessary to gain stroke on account of the lost motion due to wear in the connections, the stroke should be gained at the lever. There will be less spring put in the connections by gaining stroke in this manner, and the greater difference there is between the amount of spring and the travel of the pipe, the more certain will be the operation of the movement and the less variation will there be in the working of the movement from the lever being pulled steadily or with a jerk. We further recommend that a compensator with 14-in. crank arms will take care of the expansion and contraction of a pipe 700 ft. long, and of 1,400 ft. of pipe line if the arms are made 17 ins. long.

C. A. Christofferson, W. H. Elliot, E. D. Wileman.

OPERATION OF INTERLOCKING PLANTS BY POWER.

Question I.—"When Can an Interlocking Plant be Economically Operated by Power?"

This question cannot be determined by any set rule, or at haphazard, as the requirements of any two places are not the same, the location, and the amount and frequency of the traffic, having to be taken into consideration in deciding which style of a machine is better adapted for the work required; in general, it can be said that a power plant can be economically used: When there is a large amount of traffic to be handled or when the interval between traffic movements is so small that the question of time saved (fractions of minutes) is a point to be con-

*Held at Pittsburg, Pa., Nov. 11, 1902.

sidered. 2. When the plant to be operated is large and so located that the space which would be required for lead-outs, pipe lines and tower is too valuable, or could not be given up for such purposes, then a power plant should be installed. 3. When a plant to be operated is so divided (say by a drawbridge) or the extreme points so distant that it would require several mechanical machines to do the work, then a power plant should be installed and operated to advantage. 4. When a plant is large and the traffic so frequent that a number of levermen would be required, then there would be economy in both time and money to use power. 5. If a small plant is to be operated and it is located close to where a power plant is already established, then a power machine can be economically installed and operated.

Question II.—"At What Number of Levers (Mechanical) Would it be Economy to Substitute Power?"

This would have to be governed entirely by circumstances. You cannot say that a place which would require an 80-lever mechanical machine should be installed with power instead, as it might be at a crossing of a number of roads with comparatively few trains and quite an interval between conflicting movements; then one man would in all probability have sufficient time to handle the traffic at such a place and there would be nothing to be gained. On the other hand a place at which a four-lever mechanical machine was installed to handle a traffic which required two men on each trick to operate it, could be operated by power advantageously, so that it cannot be decided entirely by the number of levers, other things have to be taken into consideration therewith.

Question III.—"Assuming the interlocking to be at grade crossings, junction points or inlets and outlets of yards, also taking into consideration that power would have to be provided, be it either electro-pneumatic, electricity or straight air, would the extra expense incurred by such installation be overcome by a saving of labor to operate?"

It would, if at a busy place, when the difference of money expended for labor in handling the traffic would amount to enough to pay for the operation and maintenance of the power generating apparatus and pay the interest on first cost of same.

Question IV.—"How does the cost of maintaining a power plant compare with a mechanical plant?"

Practically the same (both in material and labor), but slightly in favor of power plants, the larger the plant the more in favor of power.

Question V.—"How much quicker, if any, can movements be made with a power plant than with a mechanical plant?"

Power plants are 300 to 500% faster and with a further advantage that a leverman can perform the work with practically no effort, where with the mechanical, the work would naturally lag, it being more arduous.

Question VI.—"Are the chances any greater for giving false indications with a power plant than with a mechanical plant?"

There is, of course, a chance with either, but when properly erected and maintained, one should not be more liable than the other.

E. H. Spalding, W. L. Dryden, Geo. M. Goff, W. H. Lane.

ORGANIZATION OF THE SIGNAL DEPARTMENT.

The signal system is one belonging to the Maintenance-of-Way or Engineering Department, whichever designation may be given this department. It may be considered as consisting of two parts, the general force and division forces; the general force consisting of the signal engineer and those connected with this office, while the division forces are made up of those who inspect, repair, and maintain the signal apparatus on the various divisions.

The signal engineer should report to and receive his instructions from the head of the maintenance-of-way or engineering department, and should have charge of the installation and maintenance of all automatic, mechanical, electric and interlocking signals; he should prepare plans, specifications and estimates for all new plants and superintend their erection and installation.

He should superintend the maintenance and alterations of existing plants and fixtures; he should make periodical reports relative to the operation of the signaling system under his charge. He should investigate and report all detentions of train service caused by the failure of signals, and of damage done to signals, plants and apparatus, reporting his findings and recommendations in the matter to his superior officer, the division superintendent or any other official who should take cognizance of the same.

No removals or alterations other than routine repairs incidental to the maintenance of the signals should be undertaken without the approval of the signal engineer excepting in emergency cases. All requisitions for signal supplies should be prepared and approved by the signal engineer, so as to insure uniformity and accuracy of distribution. He should be aided by such outside and office assistance as may be necessary for the proper conduct of his work, and to his office should be attached such special force as may be required for the installation of all new plants, whether mechanical or automatic, as well as for alterations to existing plants, if done by company force, or contract, where such alterations or renewals are other than ordinary maintenance, which, of course, would be handled by division forces.

The division forces should consist of such supervisors or inspectors, repairmen, batterymen and lampmen as are necessary to properly maintain the signals and interlocking plants on their respective divisions. They should be appointed subject to the approval of the signal engineer as to their fitness for such positions.

The division supervisors or inspectors should have direct charge of all mechanical or automatic signals and plants, and the men employed on the maintenance of same on their respective divisions. If the various departments making up the operating department are maintained separately, the supervisors should report to the signal engineer or his assistants. If, on the other hand, the division organization is maintained, they should report to the division engineer as the head of the division subdepartment, but should always carry out such instructions as may be received from the signal engineer as to the proper technical work.

In case they should require assistance from the division roadway forces in connection with their work, they should arrange with the signal engineer or division engineer for this purpose.

E. B. Ashby.

SIGNAL CIRCUITS.

Three-Position Signals.—The three-position signal combines in its one-arm and one-lamp, all the functions of a two-arm and two-lamp (home and distant) two-position signal. Its day and night indications ("danger," "caution" and "clear") are consistent and in harmony with interlocked signals. It reduces the number of lamps and arms, and requires no more controlling appliances or complex mechanism. Therefore, we favor it as the simplest and most economical way of giving "two-block information." We favor as nearly a uniform block of ¾-mile as conditions permit, reducing the distance slightly for up grades and increasing it slightly for down grades, so as to preserve a practicable uniform time interval between trains, at the same time giving sufficient space for the swiftest and heaviest trains to be brought to a stop between the caution and danger indications, but under normal conditions keeping the distance between the caution and danger indication approximately ¾-mile.

Type of Signal.—We favor the semaphore operated wholly by electricity, believing it to be just as efficient in operation and more economical than any other automatic signal of semaphore type. We prefer the semaphore type to the disk or banner.

Normal Position of Signals.—We favor normal position at "Clear:" (A) The controlling circuits are simpler; (B) the signals are more readily inspected and consequently easier to maintain; (C) less liable to derangement from lightning (because less apparatus and less line wires are exposed). We believe these things outweigh the claims (A) that the normally danger is the consistent position (with relation to interlocked signals); (B) is (or should be) more economical in battery consumption; (C) is less liable to give false clear indications due to defects or inclement weather affecting the signals proper.

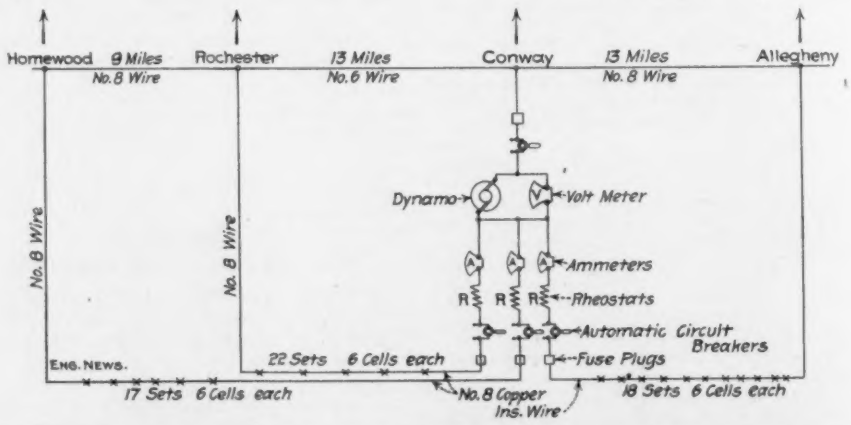


DIAGRAM OF POWER TRANSMISSION CIRCUIT FOR SIGNALS, ALLEGHENY TO HOMEWOOD; P., FT. W. & C. RY.

Setting Point.—We think it correct principle to allow a train to pull up to the signal, and wrong principle to pass danger signals. Besides, there is the objection that if the "setting point" is far enough in advance of a signal to enable an engineer on a train running 60 miles an hour to see the signal set—in foggy weather—he may not see the signal in the clear position.

Type of Battery.—There are two examples of signals supplied with power from storage batteries charged from a power line. The installation from Allegheny to Homewood (given below in some detail), and the installation from Philadelphia westward on the main line of the Pennsylvania R. R. This last is an installation of four-track road. Here track circuits as well as the signals are supplied with current from storage batteries [illegible] double track, where the blocks are more than one mile long, we do not unqualifiedly advocate the use of storage battery charged with power line, because the interest and depreciation on the extra equipment is such a big factor that the economy over the primary battery method is doubtful.

For example: The Michigan Central R. R. has a system of approximately two-mile blocks (the average being somewhat less). Signals are (one-arm) "two position," the distant signal located about 3,500 ft. from its home. The yearly cost for maintenance and operation of each signal is about $67; $10 of this is charged to battery consumption for operating signal, primary battery being used, costing about $5 per KW. hour.

If electric power at 5 cts. per KW. hour could be had (a common rate for lighting and power), the operating power for each signal would cost 10 cts. per year, reducing the total cost of maintenance and operation 16%.

Suppose we install a power line and station and transmit current for charging batteries over 40 miles (20 miles each way), this extra equipment we will say costs $6,000; interest at 5%, $300; depreciation, 10%, $600; total, $900. Cost to furnish 160-KW. hour at 5 cts., $8. Total cost per year to furnish current for 80 signals, $908. Cost with primary battery at $5 per KW. hour, $800. Difference in favor of primary battery arrangement, $108.

It is obvious that we have a big man doing a small boy's work. But there is other work to do. There are track sections which cost about $5 per year for battery, and signal lamps that cost $2 a year for oil, which require daily, or at best, semi-weekly attention, and even then are frequently extinguished by storms. These two items should be added to the work of the power transmission outfit.

The best solution of the question seems to require the perfecting of alternating apparatus, namely, the signal motor, the switch indicator and the track relay. We can then dispense with all battery and oil lamps. With such an arrangement we believe the cost of maintenance and operation for automatic signals can be reduced 50%.

Control of Distant Signal.—We are disposed to favor the wireless method. It has been found reliable and it brings within easy reach all apparatus needing frequent inspection, reduces the amount of depreciable material and affords some immunity from lightning. On the other hand it requires a slightly less efficient and more complicated track relay and does not afford as good opportunities for rendering harmless disturbances due to foreign currents on the track.

Switch Indicator.—We favor switch indicators. There is scarcely any more excuse for omitting them in a system of automatic block signaling than there is for omitting dwarf signals in an interlocking plant where reverse and subordinate movements are made. Every entrance to a block should be signaled. Switch indicators facilitate traffic by giving important and necessary information to a train about to enter a block from a switch.

We prefer the miniature signal to a bell, because its office is more important as a signal than as an annunciator. A bell not ringing (out of order) is equivalent to a clear indicator. An indicator (out of order) stands at danger. Indicators can be worked in series or multiple by one battery, whereas, bells to work satisfactorily require local battery for each. The bell is a better annunciator and may be located farther from the switch or serve for a group of switches and is as good at night as in daytime.

Track Sections.—Only one road so far as we know has included the rails of all cross-over connections in the track circuits, and only one has issued instructions calling attention to the omission with an accompanying rule to trainmen. We favor track circuit equipment for all cross-overs between main tracks and between a main track and side track. We prefer stone ballast and a track section equal to the length of the block.

The following is a description of the block signal system on the Pittsburg, Fort Wayne & Chicago Ry., previously referred to in this report:

The block signal installation on the Eastern Division of the P., Ft. W. & C. Ry. has many new features in the way of maintenance and operation. The track situation is as follows: Four tracks from Allegheny to Rochester, two tracks from Rochester to Homewood. In this distance, 35 miles, there are 188 block signals and 8 mechanical interlockings (none of the latter being at grade crossings). The blocks are from ½-mile to ¾-mile long, except through interlockings, in which case they merely extend between interlocking limits.

The block signals are three-position electric motor semaphores. The three-position signal is the standard block signal for the Pennsylvania Lines West of Pittsburg. Distant signals for interlocking are automatic signals and are located a full block away from the home signals. They stand normally at caution, that is, 45° from the horizontal, and are cleared through a circuit closer ont the home signal, when the home signal comes to the clear position.

The home signals for all interlockings are two-arm, with the lower arm mechanically connected and the upper are semi-automatic. The upper arm is worked by a circuit controller operated by the latch of a regular mechanical lever in the machine. This lever does no mechanical work except to operate the mechanical locking. The circuit is so arranged (by the use of a stick relay) that after the lever has been reversed and the signal cleared, a train passing onto the block section causes the track relay to open, which in turn causes the signal to go to danger. After a train has passed out of the block the signal will not clear again until the leverman puts his lever "home" and reverses it again.

The home signal levers are also electrically locked in the reversed position, if either the home or distant signal fails to go to danger when it should. This prevents the leverman from changing the route until the trouble has been cleared up.

The signals are operated by storage batteries placed in 5 × 7 steel wells; six cells of chloride accumulator, type D-5, are used, and their capacity is sufficient to operate four signals on a bridge simultaneously. Each well has two sets of storage cells, so that one set is charging while the other is discharging.

The charging is done as follows: Each signal repairman goes over his section, about seven bridges, the first thing each day, and throws a rotary knife switch in each battery well. This switch transfers the charged battery to the operating system and the discharged battery to the charging line. While the batteries are being charged they are cut entirely free from the operating system. The charging is done from a power station, located in the Conway roundhouse, by means of aerial charging line, into which the batteries are connected in series. The batteries are charged for eight hours each day. The voltage at the power station is 550 to 600, and over half of this is needed to overcome the drop due to line resistance.

The accompanying sketch of the charging circuit shows that the batteries are connected in three groups. The division is made so that each group can get from 1½ to 2½ amperes with all the batteries in circuit. Any well can be cut out of the line, so that in case of a break down one or two sets of battery can be charged at a high rate. The power station is equipped with engines and generators in duplicate, so that either generator can be used to charge one or all three charging groups.

The expense of maintenance and operation during the past year for 188 signals has been $5.45 per signal per month. With the three-position system one signal is equivalent to two where home and distant signals are used, and the comparison of expense should be made accordingly. J. C. Mock, W. E. Foster.

IRRIGATION SYSTEM OF THE ARKANSAS VALLEY SUGAR BEET & IRRIGATED LAND CO., COLORADO.

By W. P. Hardesty,* C. E.

(With two-page plate.)

The irrigation system about to be described was not all built at once, according to a preconceived plan, but it is mostly the result of an enlargement and a combination of existing works. By this means one of the most extensive and comprehensive systems in the West has been built up. It is located in the wide valley of the Arkansas River, in eastern Colorado, and also covers a large body of land in western Kansas.

The Arkansas is the largest river of the state. It heads in the vicinity of Leadville, in the central part of the state, and after flowing southerly for 70 miles and easterly for 50 miles, it emerges from the mountains at Canyon City onto the Great Plains of eastern Colorado.

The drainage area increases from 3,060 sq. miles at Canyon City to 4,600 at Pueblo, 9,130 at Nepesta, and 11,440 at Rocky Ford.

May, June and July are the months of greatest flow, the highest water being reached during June. The total flow during ordinary stages has been appropriated for many years. Soon after reaching the plains the water is gradually diverted by the many canals, so that by the time the Kansas line is reached the river is usually dry during the late summer and fall. There are several large canal systems depending on the river for a supply of water, and a large area of land in the Arkansas Valley has been brought under irrigation.

The system to be described is owned by the Arkansas Valley Sugar Beet & Irrigated Land Co. It consists essentially (see Fig. 1) of two large canals (one much above the other) for diverting the water from the river, a complete system of reservoirs, by which water can be supplied to land under both canal systems, and many laterals and smaller canals by which water is conveyed to the districts where needed.

The land and canals are on the north side of the river. Railway facilities are secured by the Atchison, Topeka & Santa Fe R. R., which follows the river closely from Pueblo to far into Kansas. The system in Colorado extends through parts of four counties, reaching from a point about 60 miles east of Pueblo to the Kansas line, a distance of nearly 90 miles. As a valuable aid in the operation of the system is included a private telephone exchange, with 160 miles of line and 24 transmitters.

The reservoir system is the largest on the American continent. The history and description of the upper of the two canal systems will be given first.

FORT LYON CANAL SYSTEM.

FORT LYON CANAL.—This includes the upper canals, and is sometimes called the Great Plains water system. The main canal of this system taps the river about three miles west of La Junta, and it feeds the reservoirs, which are 12 to 18 miles north of Lamar. The river has a drainage area of 12,200 sq. miles above the intake. The original canal was the Armatroub Canal, only about 6 ft. wide and 3 miles long. This was then enlarged and extended to about 15 miles. In 1887, under the name of the La Junta & Lamar Canal, it was again enlarged to a bottom width of 30 ft. at the head, and extended to near its present terminus.

In the summer of 1897 the Great Plains Water Storage Co. (the builder of the present system) began to enlarge the upper part of the canal, it having acquired a right of way through the same for its own uses. This work was completed in January, 1898.

The canal is now called the Fort Lyon Canal, and it has a total length of 113 miles. It is owned and operated by the Fort Lyon Canal Co. The enlarged portion (for joint use) is 42.2 miles long, with grades ranging from 1.584 to 5.28 ft. per mile, not including 21.9 ft. fall in the 2,000 ft. that takes in the Horse Creek flume.

The bottom width is 50 ft. from the head to 10.75 miles, 46 ft. to 27.05 miles, and 44 ft. for the remainder. The depth of water provided for throughout is 6.5 ft., and the minimum height of embankment above the bottom is 8 ft. The side slope of the cuts is 1 on 1, and the slope of the embankment next to the water is 1 on 2. An embankment is used only on the lower side of the canal, the transverse slope of the ground preventing the water from spreading out very far on the upper side where it overtops the edge of the cut.

For most of the length the transverse slopes are light, heavy cuttings on the upper side occurring only where there are low benches that break off toward the river or its tributaries. This contour of the country is characteristic of the whole of this region. The material encountered in the excavations is mostly sand, gravel and clay.

The estimated capacity of the upper portion of this canal is 2,096 sec. ft. The capacity of this as well as the other canals to be described, is calculated by Kutter's formula with $n = 0.0225$.

DAM.—The canal heads, Fig. 2, at a bend in the river, so selected that the current tends to run directly into the canal. About 100 ft. to the right of the south end of the head-gate, a wooden dam begins and extends across the river to the south side, a distance of 480 ft. The crest of the dam is formed by a row of 10 × 10-in. piles, planked on the outside and having a plank covering on the top 30 ins. wide, the upstream ends of these short plank being nailed to a sill resting on the bed of the river. A row of longitudinals connects the piles, and on the upper side of this is driven a double row of sheet piling. The fall to the apron is 6 ft., and is vertical. The apron is 27⅔ ft. long, resting on piles, and it is in three sections, the plank in the upper and lower ones parallel with the stream and in the middle one at right angles to it. The lower section, 11 or 12 ft. long, was added by the present owners after acquiring the canal. No riprap is placed at the lower end of the apron, but the bed has not scoured badly. At the ends of the dam, and also in the space between the dam and head-gate, are bulkheads made of piles with rock-filling, planked on the outside. These allow a depth of water of 6½ ft. to pass over the dam. A riprapped levee extends southwesterly from the south end of the dam for about 600 ft. to prevent water running around the dam. The bed of the river above the dam has silted up to even with the crest.

HEAD-GATES.—The head-gate, shown in detail by Figs. 3 and 4, and also shown in the view, Fig. 2, is located at the beginning of a low bluff of rock that extends some distance down and away from the stream. The structure is of brick, laid in cement, with wooden gates and platform. Under each pier or partition separating the subdivisions a row of 6 piles was driven into the bed of the canal. These were sawed off at 2 ft. to 3 ft. below grade, and each row was then capped by a 10 × 12-in. longitudinal. A wall of sheet piling was then driven each side of a row, enclosing a space 2½ ft. wide. This space was excavated to about 2 ft. below the top of the caps and filled with cement concrete. The bed of the canal for the entire width was then covered with about 2 ft. of concrete. On this the brick piers were then built, and the waterway between the piers was paved with stone. The concrete foundations for the abutments at the sides of the canal were made 4 ft. wide, resting on two rows of piles. At the upper and lower ends of the masonry structure were also driven double rows of sheet-piling, flush with the grade. A wooden apron 14 ft. long was joined to the lower end, and under its lower end was built a cut-off wall of wood and concrete, reaching down over 3 ft. The piers are 12 ins. thick, with a 16-in. footing. The abutments and their wings are 16 ins. thick, backed by concrete, and this is backed by a rock-filling. There are 13 openings of a clear width of 5 ft. each. The piers against which the gates rest are of brickwork. The abutments have stone copings. On top of the piers are timber caps, on which rests the timber superstructure. On the plank covering is placed a filling of earth and rock for a roadway over the structure. This is held in by 3-in. planking on the sides.

The gates themselves are shown in detail in Fig. 4. The cast-iron ratchet or rack bar is operated by gearing similar to that for the Amity Canal head-gate, to be described. The floor of the head-gate is 5.5 ft. lower than the crest of the dam, so that there is no difficulty in turning in a good head of water. The approaches to the dam and head-gate, above and below, are riprapped.

REGULATING GATES.—Less than one mile below the head is a set of waste or regulating gates. There are seven gates, each with a clear opening of 4 ft. 4½ ins. They and their operating gear are of the same style as for the main head-gate. There are no check gates in the canal to help divert the water to them. Some 300 or 400 ft. below here is the rating flume required by the state law for convenience in measuring the flow of water in the canal.

STREAM CROSSINGS.—Horse Creek is crossed by a flume, at 15½ miles from the head. Though usually dry, the channel of this creek is quite wide during floods, requiring a large waterway to pass the waters (carrying much silt and sand) under the flume after heavy rains. At a point 100 ft. above the upper end of the flume is a set of check gates and waste gates, the former consisting of four 10-ft. and one 8-ft. gate, and the latter of five 8-ft. gates. The flume is 600 ft. long. This includes the 250-ft. approach at the upper end, which is built of masonry resting on the natural rock formation. The approach channel is in the form of an invert, the center 2 ft. lower than the sides. It is 36 ft. wide. On the bottom was placed about 2 ft. of concrete, on which a brick pavement was laid. As much trouble was had with the current loosening and tearing out the bricks, a plank flooring was afterwards put on over them. The side walls are of brick, 20 ins. thick at the bottom and 12 ins. for the upper part. The walls are tilted back so that the front face has a batter of 1 to 4, the joints being at right angles thereto. They are backed by concrete that fills the space to the sides of the solid rock formation.

The remaining 440 ft. of flume is constructed of

*Progress Building, Salt Lake City, Utah.

timber and plank, resting on oak piles. The flume is 28 ft. wide. The total fall for the 630 ft. is 21 ft.

Adobe Creek is crossed on the level so that no opening is left for the passage of its waters. Provision is made, however, for taking care of its flood waters by a set of waste gates built across the creek bed. The clear length of waterway of these gates is 140 ft. The gates are hung from above and draw water down to a level 1.5 ft. below the grade of the canal.

Gageby Arroyo is also crossed on the level. It is only ¾-mile above Division Gates No. 1, so that these gates serve as check gates for the emptying of the canal through the waste gates at the arroyo. There are 14 waste gates, each 4 ft. 3 ins. wide in the clear. The drainage area to be cared for is nearly 80 sq. miles. These gates are of the hinged type, Fig. 5, being quite different from the other gates on the system.

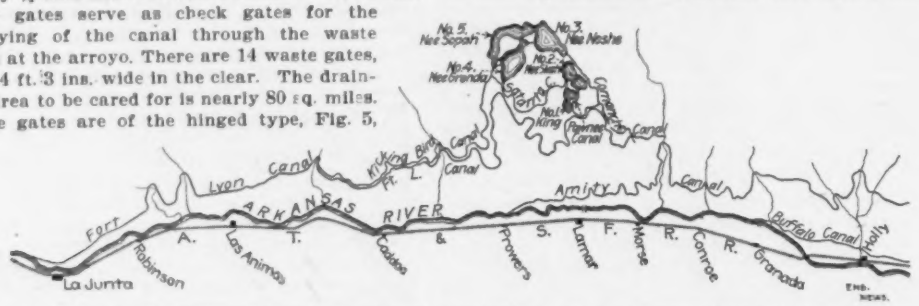


FIG. 1. MAP OF IRRIGATION SYSTEM OF THE ARKANSAS VALLEY BEET SUGAR & IRRIGATED LANDS CO., COLORADO.

DIVISION GATES.—At the end of the enlarged portion of the Fort Lyon Canal, Division Gates No. 1 are placed (see cross-section, Fig. 6). From this point the company constructed an independent canal to its reservoir sites. This canal runs on a lighter grade than the Fort Lyon, and so gradually leaves it below. The latter canal continues on to a point northeast of Lamar. It has a capacity of 460 sec. ft. just below the division, and 66.5 sec. ft. of the flow in it belongs to the owners of the reservoir system.

The Fort Lyon Canal is widened at Division Gates No. 1 to allow of the length of structure needed here. There are seven gates with a clear opening of 4½ ft. each for delivering water to the lower portion, and 10 gates with an opening of 4½ ft. each to deliver water to the Kicking Bird Canal. The structure is of timber, resting on the bed of the canal, with cut-off walls of plank and concrete at the upper and lower ends. These extend about 6 ft. into the bottom of the canal. There is also a 12-ft. apron above and a 14-ft. one below.

KICKING BIRD CANAL.—This is the independent canal mentioned above, for supplying the reservoirs. Its length is 36.5 miles. It was built during the spring and summer of 1897. The grades are 0.792 to 1.584 ft. per mile. The bottom width varies from 50 to 34 ft., and the depth of water is 6 ft. to Sta. 1710, then 5.5 ft. The capacity at the head is 1,000 sec. ft.

About 1⅓ miles above the end of the canal are located Division Gates No. 2. Here starts the Satanta Canal, which is one of the principal branches.

SATANTA CANAL.—The length is 12.5 miles. The grade per mile to Sta. 440 is 1.584 ft.; to Sta. 605, 2.64 ft., and this grade continues on to the end except for being broken by three drops. The bottom width is 16 ft. throughout. The slopes of cuts are 1 on 1, and of embankments 1 on 2 and 1 on 1½, the same as for the other canals.

At Sta. 605 is Drop No. 1, a timber structure allowing a vertical fall of 17.5 ft. Drop No. 2 at Sta. 623 has a fall of 7 ft., and Drop No. 3 at Sta. 658 (the end) a fall of 23 ft. The latter drop has five subdivisions.

These and all other drops on the system are used because the natural fall of the country along the direction of the canal line is too great for any permissible grade. A grade light enough to prevent scouring is used, and when this results in the bottom of the canal being brought near to the surface of the ground, a drop places the bottom well below the ground, it taking some distance to approach the surface again.*

*These drops may be described, in a general way, as a series of wooden boxes, at successively lower levels, with the sides at right angles to the current extending into the earth to form cut-off walls. Fig. 10 shows a variation, on the Comanche Canal.—Ed.

The Satanta Canal ends just above the high-water line of the Nee Skah or Queen reservoir, into which it empties. The capacity is 300 sec. ft.

LONE WOLF CANAL.—This branches off from the Kicking Bird Canal about ¾-mile above where the latter ends on the high-water line of the Nee Gronda reservoir. It was built as an independent feeder for the Nee Noshe reservoir. Its length is four miles, and its capacity 700 sec. ft.

RESERVOIR SYSTEM.

There are five main reservoir sites. They are natural depressions in the ground, and require but little in the way of diking to fit them for storage. Their aggregate area is about 14,000 acres. Following are their names and capacities in acre ft.:

Indian name.	English equivalent.	Capacity acre-ft. Unavailable.	Available.	Total.
Nee Sopah..	Black water	10,908	23,465	34,373
Nee Gronda.	Big water	39,890	57,209	97,099
Nee Noshe..	Standing water	21,485	60,636	82,121
Nee Skah or Queen....	White water	9,939	23,047	32,986
King.....	.....	...	18,279	18,279
Total	.....	82,192	182,636	264,828

The available draw-off depth in the Nee Noshe, Nee Gronda and Queen reservoirs is 22 ft., that in the Nee Sopah 12 ft., and in the King 20 ft. The depth of the three upper reservoirs, Nee Sopah, Nee Gronda and Nee Noshe, can be increased by 5 ft. with little extra trouble. The King reservoir is not yet developed. The method of using the reservoirs is as follows: The Nee Sopah and Nee Gronda are fed directly by outlets from the Kicking Bird Canal; the Nee Noshe is fed by the Lone Wolf Canal, and the Queen is supplied by the Satanta Canal. The Nee Sopah and Nee Gronda are directly connected by a cut near the south end, and both discharge into the Nee Noshe, whose water level is at the same elevation. The water from these three reservoirs is drawn out of the southeast end of the Nee Noshe by the Comanche Canal; that from the Queen by the Pawnee Canal, heading at its south end.

At the southeast end of the Nee Noshe reservoir a dike or levee 4,000 ft. long had to be built. This is of earth, with side slopes of 1 on 4, and a top width of 25 ft. The maximum height is near the northeast end, at the outlet gate, and is 9 ft.

A large levee was needed, also, at the south end of the Queen reservoir. This levee is 3,000 ft. long over all, and it has side slopes of 1 on 2½, and a top width of 18 ft. The maximum height, at the outlet gate, is 17 ft. By reason of the strong winds from the north, the water slopes of the levee is riprapped with broken rock. The top surface slopes slightly toward the riprapped side, and near the inner edge is dug a shallow drain. About every 100 ft. a wooden trough takes the water collected by this and discharges it 10 or 15 ft. distant down the riprap.

COMANCHE CANAL.—This is the canal that draws water from the southeast end of the Nee Noshe reservoir. Its head-gate is located on the line of the levee before described. This structure, shown in the view, Fig. 7, is of sandstone and limestone masonry, laid in cement. The outlets or gates consist of four cast-iron pipes, each 30 ins. in diameter. These extend through the bottom of the masonry on the grade of the bottom of the canal, as shown by the view, Fig. 8, taken while the head-gate was under construction. Details of the whole structure are shown by Fig. 9. The lines of pipe are but 20 ft. long, and each of the two pairs discharges into a masonry culvert. Each culvert is 7½ ft. wide, with vertical sides and an arched roof. The clear height is 5 ft. These culverts continue the conduit through to the toe of the earthen embankment that overlies them. At the upper end of each of the pipes, and nearly flush with the face of the stonework, is a water valve for regulation. The high-water level of the reservoir is 22 ft. above the bottom of the pipes and the canal. The valves are operated by stems, supported by brackets on the face of the wall and reaching to the top. The stems are raised and lowered by beveled cog gearing at the top, the power being applied by a vertical hand wheel. Below the mouth of the culverts is an open masonry channel 30 ft. long, succeeded by a dry wall section 40 or 50 ft long.

The canal is in thorough cut for a considerable distance each side of the outlet or head-gate. The length is 16 miles; fall, 1.584 ft. per mile; bottom width, 18 ft.; height of embankment, 6 ft. The capacity is 400 sec. ft.

There are eight drops along the canal with a total fall of 106.5 ft. Drops A, B and C have falls of 14 ft. each; Drop D, 9½ ft.; E, 10 ft.; F, G and H, 15 ft. each.

Drops A, B and C are substantial structures of timber resting on oak piles. The fall is in three subdivisions of 5 ft., 5 ft. and 4 ft. Each structure is 14 ft. wide inside and 56 ft. long, and there is a short paved approach above and a dry wall section below. The planking used is 3 × 12 ins.; 1-in. batten is nailed over the joints inside of the planks to make watertight. These drops are peculiar in having a roof or top over the water

FIG. 2. VIEW OF DAM AND HEAD-GATE, FORT LYON CANAL.

channel, the object being to prevent the too-quick drying out and warping by the sun of the wood. They were put in during the winter of 1900-1901. The other drops were put in some time before. They differ considerably from the ones described. Drops D and E have two subdivisions, and the other ones have three. A plan and section of Drop D is shown by Fig. 10.

At the end of the excavated channel the water of the Comanche Canal is turned loose and allowed to run down a natural channel or gulch to

the flat or valley traversed by Big Sandy Creek, a distance of about two miles. It follows down this a short distance, when it is taken up by the Amity Canal, to be described further on.

PAWNEE CANAL.—This is the outlet of the Queen reservoir. Its length is 6.30 miles; grade, 1.584 ft. per mile; bottom width, 12 ft.; height of embankment, 5 ft.; capacity, 200 sec. ft. The head-gate is on the line of the levee before mentioned. It is nearly the same in design as the one at head of the Comanche Canal. There are three

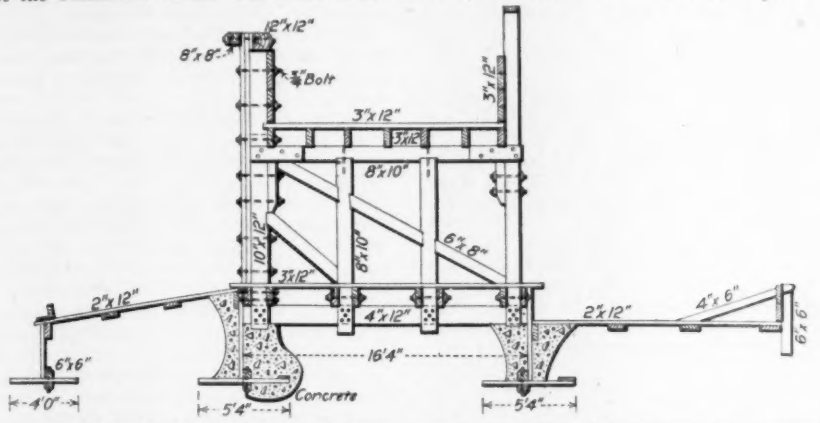


FIG. 6. CROSS-SECTION OF DIVISION GATES NO. 1, AT HEAD OF KICKING BIRD CANAL.

openings of cast-iron pipe, each 30 ins. diameter, and these discharge into one arched masonry culvert which passes under the embankment to its lower side. The entry of water to the pipes is controlled by valves at their upper ends. These are operated by gearing that is much smaller and also simpler than that for the Comanche head-gate. A small cog on a horizontal shaft, turned by a crank handle, engages the large cog wheel on the valve stem, the latter wheel having radial teeth on its upper surface.

The flood level of the reservoir is 22 ft. above the grade of the canal head. The canal runs down near the east side of the King reservoir site, then turns to the east through a low saddle, and finally discharges into the Comanche Canal shortly below Drop C of the latter (Station 383).

As shown by the map, Fig. 1, the reservoir system and its feeder and outlet canals can be used to irrigate a large body of land directly under them, as well as to supply water to the Amity Canal. The reservoirs were developed and their outlet gates and canals built during 1898.

This kind of reservoir should be much superior to one made by the damming of a natural water course, where there is danger of the dam giving way unless every precaution is taken in its construction. The supply to them is under control of the owners, and there is no danger from floods. There should be very little sediment deposited in them, which has proved to be a very serious factor in the case of reservoirs occupying a stream bed.

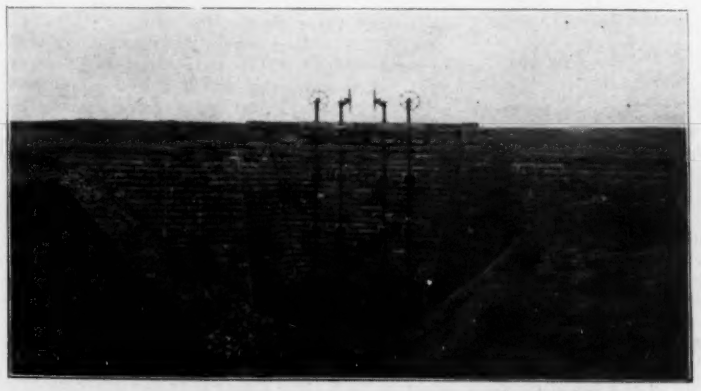


FIG. 7. VIEW OF NEE NOSHE HEAD-GATE, COMANCHE CANAL.

FIG. 8. NEE NOSHE HEAD-GATE UNDER CONSTRUCTION; LOWER END OF OUTLET-PIPE ENCLOSED IN MASONRY.

AMITY CANAL SYSTEM.

AMITY CANAL.—This canal heads seven or eight miles west of Lamar. The original canal was built in 1887. The Amity Land & Irrigation Co. was organized in 1894 and acquired the canal. A new head-gate was built, and in December enlargement of the canal was begun. It was enlarged to 55 miles from the head, and from there on an entirely new canal was built. This extends into Kansas for about 30 miles. The work was completed in the fall of 1895. The total length is 110 miles.

Following are the grades in feet per mile: Sta. 0 to 1,362, 1.056 ft.; to 2,060, 1.637 ft.; to 2,100, 1.32 ft.; to 2,496, 1.584 ft.; to 2,690, 1.162 ft.; to 3,113, 1.584 ft.; and 1.056 grade for the remaining distance. The bottom width starts at 32 ft. at the head and gradually reduces to 24 ft. at Sta. 1,362, and thence to 14 ft. near the end, the reduction, however, being broken by an increase in width to 24 ft. from Sta. 2,496 to 2,690. The height of the bank for the upper part is 7.5 ft.; at Sta. 423 it reduces to 7 ft.; at 1,362, to 6.5 ft.; at 2,496, to 6 ft.; at 3,233, to 5.5 ft.; at 3,970, to 5 ft.; and at 104.5 miles from the head to 4.5 ft. The side slopes of the channel cut are 1 on 1; for the embankment the slope of each side is 1 on 1½ to Sta. 2,496, beyond which the inner side has a slope of 1 on 2. The canal at the head has a capacity of 870 sec. ft.

DAM.—The dam for diversion of water into the Amity Canal is 365 ft. long, and extends directly across the river. As reconstructed in 1894, it is of timber, resting on piles spaced 4 to 5 ft. c. to c. Many of these are driven to bedrock. Forming the crest is a row of piles capped by a longitudinal timber. Nearly the whole of the head of each pile is cut away to receive the timber, which is bolted, and also drift-bolted, to it. On the upper side of the posts is nailed a plank wall, reaching down to 3 ft. below the cap. Two other rows of piles, spaced 4 ft apart, are on the upper side of the first row, and each is capped by a longitudinal. On top of these, sloping down towards the bed of the stream, is spiked a covering of 3-in. plank; 6 × 8-in. braces are also placed between the rows, at some distance down, on top of which is a layer of poles, and the space up to the plank covering is filled with loose rock. The plank covering has a downward slope of 1 on 2, so that its upstream edge is 4 ft. below the crest of the dam. On the upper side of the structure is driven a row of 4-in. sheet piling. There is a fall of 4 ft. from the crest of the dam to the apron. The latter is 30 ft. long. It is in two sections, the upper or main one being about 1 ft. higher than the lower one. It rests on longitudinals, one line bolted to the face of the main row of piles and two other lines bolted to either side of the heads of each of four other rows. The covering is of 4-in. plank.

At the lower end of the apron were placed mattresses of brush, but the iron wire with which they were bound rusted out, and so they washed away. Rock was then thrown in, but this gradually sunk much below the main bed by the scouring out of the material below it. No trouble has resulted from this condition, however. During floods the depth of water passing over the crest of the dam has been as much at 5½ ft., reaching 6 ft. in 1895. At these great depths the level of the water falls not much over 1 ft. in passing over the dam, on account of the depth in the river below. The bed above the dam has silted up to within less than ½ ft. of the crest.

At the ends of the dam are timber abutments or bulkheads. These confine the water to the dam. The one at the south end is of piles with earth filling, the latter being confined by a wall of 3-in. plank around the outside. Both abutments are riprapped above and below.

For a length of 30 ft. of the dam next to the north abutment, a different construction is used for the crest. There are braces or frames, made of angle iron, 5 ft. apart, supporting on their upper side a plank facing brought up even with the rest of the dam. These planks can be removed one by one, so that the crest can be lowered down to the apron, 4 ft. below the main crest, forming a scour gate. By this means the entire flow during low water can be diverted from its passage over the main dam, and the silt accumulating above the adjacent head-gate can be washed away.

All the wood continually covered by water has remained perfectly sound, but the upper parts of the main piles and other timber not saturated have decayed badly. The piles are of cottonwood, but they have remained perfectly sound except where exposed to the water and air alternately. During much of the year all the water in the river at this point is taken into the canal without touching the dam at all. During the winter of 1901-2 the dam was still further altered or repaired in the following manner: A triangular trestle of 6 × 8-in. timbers was erected on the apron for supporting a new crest, about 1 ft. higher than the old one. Both the back and front are sheeted with planking, the former on the same slope as the original back. The north bulkhead was built up of heavy masonry laid in cement, on a concrete foundation.

HEAD-GATE.—This adjoins the north end of the dam. It is built of timber and plank. There are eleven openings of a clear width of 4½ ft. each. At the upper end of the structure provision is made for shutting off all water, by means of stop plank. By this arrangement the water can be cut off entirely before reaching the gates, 4½ ft. further down stream, by which the latter can be inspected and repaired when needed. The sill of

the head-gate is 4 ft. below the level of the old crest of the dam.

The openings for the stop-planks and the gates do not extend the full height of the structure, but only for 6 ft. from the bottom. The space above this is permanently closed by planking. The water at times has stood as much as 10 ft. deep over the sill.

The dam and head-gate are located just below the head of a low ledge of sandstone that runs near the river here, on the north side. During high water the driftwood coming down the river does not reach the head-gate, by reason of the fact that the current strikes the rock bank shortly above, and the deflection throws it out again so that it carries the drift over the dam. There are wings on the upper and lower sides of the head-gate, and dry-rock walls and riprap are extended from these to prevent washing by the agitated current.

The gates are made of 3-in. plank, cleated together, and are 6½ ft. high by 4 ft. 10 ins. wide. Extending down the middle of each one is a 6 × 6-in. stem, bolted to it, which reaches to the top of the structure. On the rear face of the stem is fastened a rack bar.

The gate is raised and lowered by means of a cog, whose teeth mesh with those of the rack. This cog is mounted on a shaft between two bearings. On one end of the shaft, extended outside the bearings, is a wheel about the same size as the cog wheel. Around the circumference of this are sockets, and the wheel and cog are turned by means of a lever that enters the sockets. A depth of 5½ ft. of water is the greatest that has been turned into the canal.

SECONDARY HEAD-GATE.—This is nearly one-half mile below the main head-gate. It is for more completely controlling the amount of water in the canal, and also serves as a sand-gate. It consists of a set of check-gates in the canal, and of a set of waste-gates in the lower bank of it, by which water in the desired amount is turned out of the canal and allowed to return to the river, about 300 ft. distant. There are nine check-gate openings, each 4 ft. 7 ins. in the clear. Only seven are used with the present width of canal. There are five waste-gate openings, each 4 ft. 7 ins. in the clear. The two sets of gates are built in the same structure; five wooden ducts or conduits are built, 2 ft. high in the clear, starting from the upper end of the main structure and curving around so as to deliver the silt-laden water at each of the waste-gates. The current in the main canal, of course, passes on over the top of these. The gates and operating gear are practically the same as for the head-gate. The main structure is also much the same, except for the waste or sand-gates in the right-hand side of it. The approach walls or wings are of timber, and adjoining these is stone riprap. The floor of the waste-gates is placed 2 ft. 3 ins. lower than that of the check-gates, by which a strong current along the bottom of the canal can be created, which washes accumulated sand and silt through the waste-gates. By this means a strong draft is created that extends to above the main head-gate, scouring away the silt above the same and also in the canal down to the secondary gate.

The Amity Canal is peculiar in not having a flume on its entire line. It closely follows the contour of the country. About two miles above the crossing of Big Sandy Creek the canal cuts through considerable limestone rock. The wide sandy flat traversed by this creek is crossed on the level. There is a set of waste-gates to take care of the water that comes down the creek during floods and flows into the canal. The water can be entirely diverted to them by means of a set of check-gates in the canal. There are five of these, each 4 ft. 7 ins. wide in the clear. There are five waste-gates, each 4½ ft. wide. The gates and operating gear are similar to those at the head of the canal. Their capacity is not nearly large enough to take care of the floods that come down, and if this plan is continued it is intended to build an overflow weir about 150 ft. long. Immense quantities of earth have been brought down by the water from the Comanche Canal, where it runs freely down a gulch and discharges over the flat bed of the creek at about ½-mile above. This has destroyed the grass growing above the crossing of the Amity Canal, and the silt and sand have often partly filled the channel of this canal. This reduces its capacity for taking care of the water, and its embankment has often broken on this account. In operating the waste-gates, much of this silt can be flushed out through them.

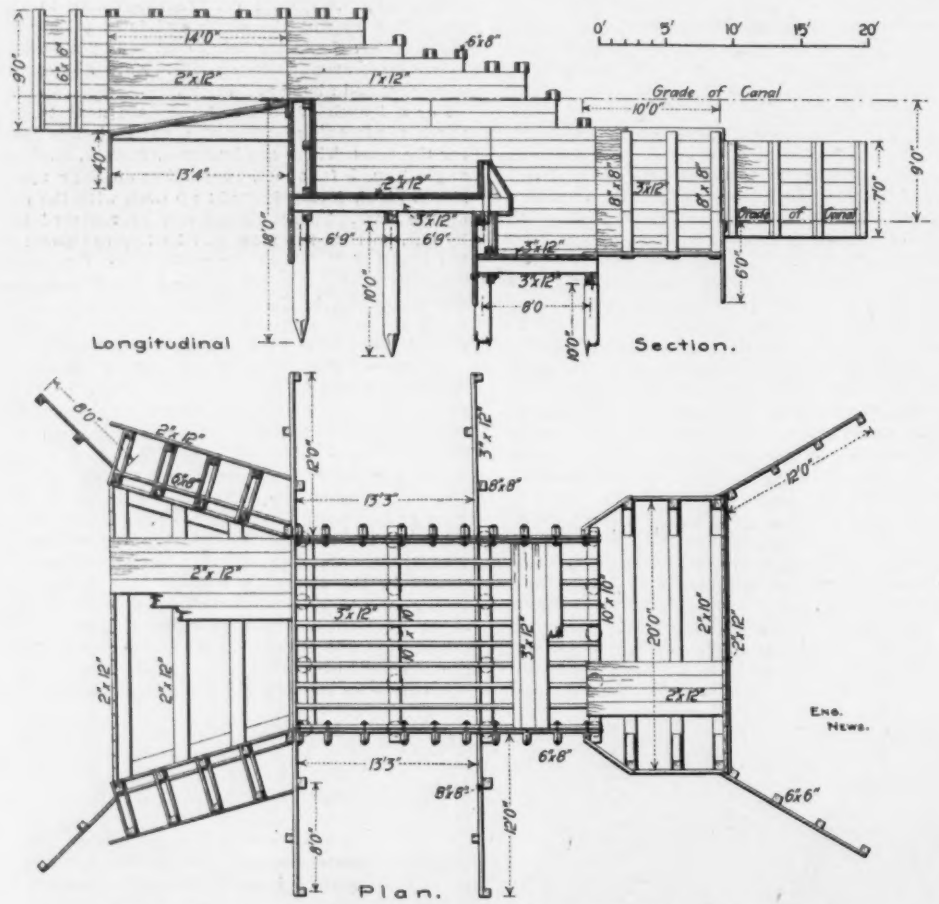


FIG. 10. PLAN AND LONGITUDINAL SECTION OF DROP D, COMANCHE CANAL.

It is intended in the near future to make a radical improvement in the handling of water in this locality. A flume or pipe will likely be built across the flat in place of the present open canal, and the water from the Comanche Canal will be brought down in such a manner that no further trouble with silt will be had. The plan that is figured on contemplates an extension of the Comanche Canal to the Amity Canal by means of a 44-in. cast-iron pipe, and carrying the latter across Sand Creek by an inverted siphon of three lines of 44-in. cast-iron pipe.

The Sand Creek crossing is 30 miles from the head, and the waste-gates here are the first ones below the secondary head-gates. The next set is 20 miles further down.

The Amity Canal, including the dam and head-gate, cost upwards of $500,000. The main laterals from it are constructed by the company, and the small laterals from these, to deliver water to the different users, are built by the farmers themselves. A water right, as sold by the company, means enough water to cover 40 acres of land to a depth of 24 ins. It is provided that 18 ins. of this will be delivered during what is generally known as the irrigation season, and the remaining 6 ins. during the winter. This division is made for the reason that winter irrigation is important for some crops and for preparing land for spring work. This water-right system, providing for a total amount of water per year instead of a continuous flow, should result in very much less waste than under the old system, where often the amount of water that would be delivered during an irrigation season, say, of only four months, would be sufficient to cover the land to a depth of several feet. The duty of water should be much higher than ordinarily, with a supply of only 2 ft. in depth during each year.

The rainfall in this locality averages 14 ins., making 38 ins. the available supply to the land.

Nearly all the land so far irrigated by the company is under the Amity Canal, and is in the eastern part of Prowers county, not far from the Kansas line. The town of Holly, on the railroad and north side of the river, is the local headquarters for the irrigated district. One of the three colonies established in the United States by the Salvation Army is at Amity, under this system.

BUFFALO CANAL.—This is the lowest canal, taking water from the river, that is owned by the company. It heads north of Granada, about 15 miles west of the state line, and runs to the Kansas line. It is 16.1 miles long, and has an estimated capacity of 192 sec. ft. It was purchased by the company in 1895.

GENERAL.—The canal and irrigation system as so far developed will irrigate about 50,000 acres of land. The company has acquired about 85,000 acres, of which 20,000 acres have already been sold. The present company acquired the entire properties in June, 1901, they having been previously owned by the Great Plains Water Co. and the Amity Land Co. The new company is closely allied with the Oxnard Construction Co., of New York, whose business is the building of sugar factories. The raising of sugar beets will likely become the chief feature of farming under the irrigation canals. It has already become a very important item among the products of older communities further up the river. The Rocky Ford factory consumed the product of about 11,000 acres in 1901. The Sugar City factory, also in the Arkansas Valley, but on the Missouri Pacific Ry., used the beets from about 5,000 acres. Beets raised under the Amity Canal are at present shipped to Rocky Ford. The first crop was raised in 1900. The beets averaged about 15 tons to the acre, and ran 15 to 18% in saccharine matter.

Work on the two systems of canals was conducted by Mr. E. C. Hawkins as chief engineer from the spring of 1894 till that of 1898. All work since then has been in charge of Mr. Thos. Berry, the present chief engineer of the company, with headquarters at Lamar, Colo. The resident manager is Mr. W. M. Wiley, located at Holly, Colo. The head office of the company is at 32 Nassau St., New York city.

A WATER-WHEEL GOVERNOR OF NOVEL CONSTRUCTION.

Two mechanical novelties are embodied in a water-wheel governor, recently patented and built by the Replogle Governor Works, of Akron, O. The governor is actuated by a control element of the centifugal ball type. This latter is so arranged, however, that it responds not only to sustained changes in speed, by centrifugal effect, but also to sudden or momentary speed variations, in a similar manner to the operation of inertia shaft governors. This combination of inertia and centrifugal control in a governor of the centrifugal ball construction is new, we believe, and a description of the governor may therefore be of interest.

The second element of novelty in the complete mechanism is the means by which the control element just mentioned is arranged to set in motion the machinery that produces the governing effect upon the source of motive power, as, for instance, in closing a valve. This is accomplished by a reversing friction clutch of an unusual construction. The complete machine, intended especially for governing turbine water wheels, has been given the name "Replogle Differential Relay" governor.

The control element of the machine is shown in Fig. 1, the drawing being reduced to diagrammatic form in order to bring out clearly the manner of action of the mechanism. A vertical spindle, driven from the shaft of the machine to be governed, carries two pivoted arms weighted with balls at their outer ends in the usual manner. In the ordinary governor of this form these arms are connected by means of rigid links to a sliding sleeve which actuates the governing mechanism. These links are replaced in the present machine by short pieces of chain, which form a flexible suspension. They are attached at their lower, inner ends to a heavy horizontal wheel mounted loosely on the governor spindle, and the operating sleeve is formed by the lower part of this wheel. The wheel is free to rotate about the spindle, and during operation is driven solely by the tangential drag of the suspension chains.

The action of this device is as follows: Suppose the water wheel, or other machine which the governor is to control, to be running at a speed higher (or lower) than normal, without regard to the manner in which this speed-change was brought about. The pendulum arms then simply swing out farther (or less far) than normal, and the higher (or lower) position of the governor sleeve determines the controlling effect, just as in any other centrifugal ball governor.

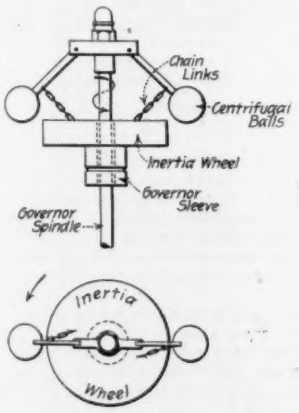


Fig. 1. Inertia Governor of the Centrifugal-Ball Type as Used on the Replogle "Differential Relay" Waterwheel Governor.
Replogle Governor Works, Akron, O., Manufacturers.

On the other hand, suppose that when the speed is normal, a sudden change in speed takes place, say an increase of speed due to reduction of the load on the water wheel or other cause. The governor spindle of course takes part in this sudden increase in speed, as do also the weighted pendulum arms. But the horizontal inertia wheel, due to its flexible suspension, cannot immediately follow the increase, and therefore it lags back. This increases the slant of its suspension chains, and therefore slightly raises the inertia wheel itself, by an amount depending upon the "suddenness" of the speed-change. This higher position of the inertia wheel with the attached governor sleeve produces through the rest of the mechanism a controlling effect tending to check the speed of the machine, just the same as would be caused by a sustained speed sufficient to raise the pendulum arms, by centrifugal effect alone, an equivalent amount. In this way a sudden change of speed is counteracted by a governing effect long before the centrifugal action alone would be effective. At the same time, the centrifugal principle of the governor is in no way affected, and comes into play with any sustained variations of speed from the normal.

The other feature of the "differential relay" governor referred to above is the friction clutch by which the control element sets in motion the mechanism which carries out the governing This clutch is shown, also diagrammatically, in Fig. 2. Two cup-shaped friction wheels (a) are driven in opposite directions from some source of power by any suitable arrangement of gearing, for instance, the arrangement shown in Fig. 2. Between these cups (a) is a spherical friction wheel (b) on a shaft set at right angles to the common axis of the cups. The lever from the governor sleeve (of the control element already described) is adapted by a shifter fork, as shown, to move the friction sphere (b) in the direction of its axis of rotation. Since the cup frictions (a) can yield slightly in the direction of their shafts against the pressure of suitable springs, any shifting of the sphere (b) will bring it into contact with the cups (a) at different points.

The two extreme positions of the sphere, for instance, are illustrated by the sketches A and B in Fig. 2. From these it will be seen that the entire arrangement constitutes a reversing friction gear, adapted to produce rotation in either direction from a source of power having rotation in only one direction. It will also be seen that this friction gearing yields variable speed; thus, when the spherical wheel (b) is in a central position there will be no tendency to rotate imparted to it, while as it moves away from this central position it gears from the cups (a) at an increasing ratio.

In the form in which this device is applied to the "differential relay" governor it is constructed with the cup frictions (a) fitted with sole leather interior surfaces, except at the center, where a lignum-vitæ block is inserted to take the wear from rotating in contact with sphere friction (b)

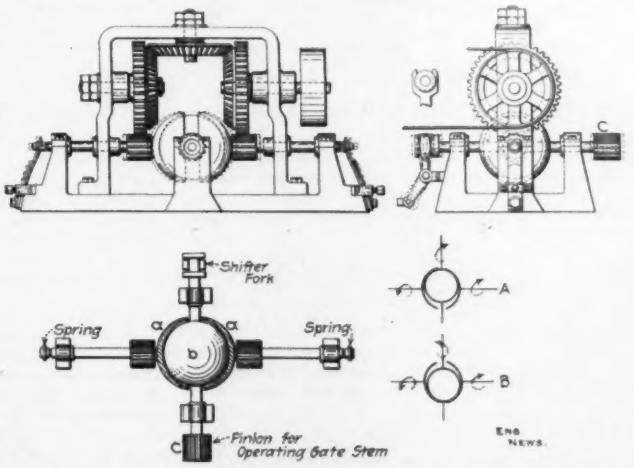


Fig. 2. Reversing Friction-Clutch Used on Replogle "Differential Relay" Waterwheel Governor.

when latter is in central position. The sphere (b) is of cast iron. The cups (a) are driven constantly in opposite direction, as already stated, from any suitable source of power, and the actuating lever from the control element is arranged to shift the shaft of sphere (b) in a longitudinal direction. Thus, at normal speed the cups (a) communicate no rotation to the shaft of (b); when the speed departs from normal, however, the control element responds by shifting its governor sleeve, and this, by means of its connecting lever, moves sphere (b) away from its central position. It then is rotated by cups (a) as a friction gear, and through the pinion (c) on its shaft it operates the gate mechanism of the water wheel.

The direction and amount by which sphere (b) is shifted depends, through the control element, upon the direction and amount of the speed variation and also upon the suddenness with which

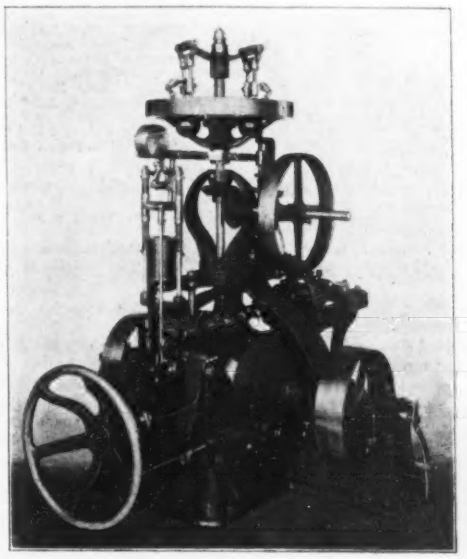


Fig. 3. View of Replogle "Differential Relay" Waterwheel Governor Complete.

this variation takes place. It will be seen that a slight displacement of sphere (b), corresponding to a small speed variation, will give the friction-pair (a) (b) a very high reduction ratio, and produce a very slow motion of the water-wheel gate. On the other hand, a larger speed variation gives a lower gear ratio and hence a quicker motion of the gate. The governor thus produces a corrective action proportional to the irregularity of the motion; but the corrective action is proportional as well in the speed with which the correction is brought about, as in the amount of correction. This feature is largely instrumental in securing steady running, keeping the variations of speed from the normal down to a minimum, and at the same time avoiding oscillations of governing due to excessive correction for small deviations.

The complete governing machine is shown in Fig. 3, in half-tone from a photograph. The picture will probably be clear without additional explanation. It may be mentioned that the hand-wheel in the foreground is ordinarily disconnected from the shaft of the sphere friction wheel, but may be thrown in gear with this shaft when it is desired to operate the gate mechanism by hand. The lever connection between the control element and the reversing friction is not of the simple form shown in the diagram Fig. 2, but acts to substantially the same end. The view shows very clearly, however, the centrifugal ball governor, with inertia wheel suspended by short pieces of chain, and the cup and sphere reversing friction, which are the two special features of novelty of the machine. The inventor of both these devices is Mr. M. A. Replogle, M. Am. Soc. M. E., of Akron, O.

GOOD PRACTICE IN THE USE OF THE DISTANT SIGNAL.*

By W. H. Elliott.†

The constant discussion of the subject both at the club meetings and elsewhere, makes it evident that the subject is still an interesting one, and either the practice on the several roads is very different, or else it must be somewhat difficult to properly maintain and operate these signals.

In answer to inquiries addressed to several roads asking

*Abstract of a paper read at the annual meeting of the Railway Signaling Club, at Pittsburg, Pa., Nov. 11.

†Signal Engineer; Chicago, Milwaukee & St. Paul Ry., West Milwaukee, Wis.

the distance that the distant signal is ordinarily placed from the home signal and the length of the longest wire line in use, the following replies were received:

D., L. & W. R. R.—No standard distance. Distant signals are put all the way from 1,200 to 3,000 ft. from the home, according to locality.

Erie Ry.—Standard distances 1,200 to 1,800 ft.

Michigan Central R. R.—No standard distance specified. At the last interlocking put in, 1,800 ft. was used. Distant signals are 1,200 ft. away from the home in the majority of cases.

Chicago, Milwaukee & St. Paul.

C., M. & St. P. Ry.—1,200 ft. Longest wire line, 3,100 ft.

L. S. & M. S. Ry.—Have been using 1,200 ft., but will put signals 1,500 ft. with future installations. Longest line, 2,200 ft.

Chicago Great Western Ry.—Standard distance, 1,200 ft. Longest line, 2,000 ft.

Chicago & Alton Ry.—1,200 ft. Longest line, 2,000 ft.

Illinois Central Ry.—1,500 ft. Longest line, 3,000 ft.

C., B. & Q. Ry.—1,500 ft. Longest line, 3,000 ft.

B. & O. Ry.—1,500 ft. Longest line, 2,050 ft.

C. & N. W. Ry.—Standard distance, 1,500 ft.

C. & W. Ind. Ry.—1,500 ft. Longest wire line, 2,500 ft.

Lehigh Valley Ry.—1,800 ft. Longest line, 3,000 ft.

N. Y., N. H. & H. Ry.—1,800 ft. Longest line, 3,125 ft.

Penn. Lines West of Pittsburg.—2,000 ft. Longest line, 2,000 ft

N Y. C. R. R.—Standard distance, 2,000 ft.

C., C., C. & St. L. Ry.—Standard distance, 2,500 ft. Longest line, 4,000 ft.

Pennsylvania Railway.—Distances vary from 2,500 to 3,000 ft. Longest line, 4,500 ft.

Pittsburg & Lake Erie Ry.—Have no mechanically connected signals. At a power operated interlocking plant distant signals were placed 1,600 ft. from the home.

These replies show that the roads have been and are putting the distant signals further away as the speed of trains increased, for 1,200 ft. was the distance that the distant signal was put from the home signal on most roads so short a time as 12 years ago. Undoubtedly at places where the distant signal is only 1,200 to 1,500 ft. away from the home signal, it is expected that the engineman will be able to see the signal before he reaches it and that in bad weather conditions the train will have to be brought under control before reaching the distant signal.

In defining the distant signal as "A fixed signal used in connection with a home signal to regulate the approach thereto," the American Railway Association recognizes that this signal will be the governing signal in determining the speed at which a train will approach the home signal, and if this signal is to be so used, it must, to properly answer the purpose, be so placed that enginemen after passing it, will have space enough in which to control the speed of the train. If the speed of trains is to be so high that they can not be stopped in the distance between the distant and the home signal, then the distant signal must be put further away than is now being done. No arrangement of mechanical connections is now in use whereby the signal can be properly operated far enough away to allow our fastest trains to be brought to a stop in the length of track between the distant and the home signal. Safe working and expense both require that the signal be put as near to the home signal as is possible and in striving for the proper medium between a distance that is impracticable and one where there is no distance at all, a distance of 1,200 to 1,500 ft. would seem to be better practice than a greater distance.

In our western country the track between the distant and the home signal, in the majority of instances, is straight and the home signal can be seen almost as far away as the distant signal. In these cases the distant signal is not needed, except in bad weather, and as these bad conditions do not occur nearly so often as good, the times when the trains have to reduce speed before reaching the distant signal have not occurred often enough to warrant putting the distant signal further away than is now being done.

It is, of course, objectionable to have trains slow up if the distant signal is not far enough away from the home signal to prevent this, and while we trust to the safe working of the distant signal and expect enginemen to be governed by its indication, is the signal so sure in its working that it may be put far enough away to properly answer the purpose for which it is intended. This is a condition that should be considered and thoroughly discussed. Our distant signals have occasionally given a clear indication when the home signal was in the stop position and while no serious accident may have happened from such failure, it can not be said that it will not be the cause of one af almost any time.

It is a comparatively easy thing for a wire connected signal to get out of order and give a wrong indication even with the connections put in the best manner possible. The wires get out of adjustment and the signal droops unless the lever is working with considerable force. If the wires are adjusted tightly to keep the arm from drooping, a broken back-pull wire will resut in the arm being pulled to give the clear indication. If a coating of ice collects on the pulleys, as usually happens several times during a winter, a signal remaining in the clear position for a very short time will be held in that position when the lever is put normal. If the wires get twisted or catch in a wire pulley nearer the pole than the lever, the lever can be put normal with but little additional force, so little indeed that it is seldom noticed by the signalman. With ice and snow on the pulleys there is often sufficient resistance in cases where the down-pull wire has been adjusted the tightest, to hold the signal in the clear position when the lever is put normal.

Although the work may be put in and maintained in the best manner possible and every endeavor be made to get the signalmen to properly perform their duties, the fact remains that our apparatus fails and the signal sometimes gives a wrong indication.

Mr. Rosenberg, of the Lehigh Valley Ry., writes:

The longest wire that we use, or have in use, is 3,000 ft., but I do not hesitate to say that it is a failure, as there are times when the lever can be pulled in either direction and will not move the signal proper more than 10°. I doubt if a distant signal will work properly over 2,000 ft. away, especially if there are any curves to meet.

Mr. Mock, of the Michigan Central Ry., advises:

I am of the opinion that we should get our distant signals out farther than 1,200 ft. from the home, but am unwilling to specify mechanically connected signals a greater distance than 1,200 ft. from the lever, without compensators (and I have not much faith in the reliability of compensators). The present traffic requires a location of the distant signals out farther and the only solution of the question which presents itself to me is the use of power signals equipped with repeaters locking derails closed while in the clear position.

Mr. Dunham, of the Illinois Central Ry., says:

The greatest distance we are operating a mechanical signal is 3,000 ft. I would state, however, that the signal referred to has not been entirely satisfactory for the reason that we have so much trouble in keeping the wires properly adjusted.

Mr. Grafton, of the Pennsylvania Lines West of Pittsburg, writes:

In the last two or three years, owing to the high speed of trains and certain conditions, we have been placing distant signals 2,000 ft. from the home signal. This, I consider, the maximum distance that you can work a distant signal satisfactorily mechanically connected. We are now figuring on putting up electric semaphore signals for distant signals.

Mr. Christofferson, of the Chicago Great Western Ry., evidently has little trouble with long-wire lines, for he says:

The longest wire line we have on the C. G. W. Ry. is about 2,000 ft. I wish, however, to say that I have worked wire-connected signals successfully 4,800 ft. from the tower. We, of course, use wire compensators in all our wire lines over 700 ft.

Mr. Fowler, of the Pennsylvania R. R., advises that:

At one or two of our interlockings the distant signals is 4,500 ft. from the cabin, but we do not approve of this and are considering the advisability of installing electric distant signals when the distance is over 2,500 ft. between the home and distant signals. We have now several electrically operated distant signals which are giving very good results.

With the long wires giving trouble to operate, is it not the best practice to put the distant signal as close to the home signals as the operating department can get along with than to try and operate the signal at the maximum distance that the signal can be worked and where the chance of failure will be greatly increased? With derails placed 500 ft, from a fouling point and the distant signal 1,500 ft. from the home the connecting wires will average 2,075 ft. in length. Where switches are placed 1,400 to 1,900 ft. from the tower as they are at many plants the distant signal will be 2,975 to 3,475 ft. from the lever and at these distances it must be admitted it is a very uncertain matter to operate the signal properly.

The apparatus ordinarily provided by the signal companies is as simple as possible, consisting of the lever in the machine, the two lines of wire to the signal, the balance lever on the signal and the connections from the lever to the signal arm. The balance lever is provided with a weight usually of about 10 lbs., which is expected to overcome the weight of the arm and require force to be exerted in the clearing of the signal. With this light weight, a slight pull on the down-pull wire will lift the weight if the back-pull wire is disconnected, and in order to guard against the signal being pulled to clear when the back-pull wire breaks, the wire must be kept loosely adjusted. With the wires loosely adjusted the signal will not come down to the clear position when the lever is pulled unless the lever is moved with a jerk or quick motion at the end of the movement, and therefore the proper clearing of the signal depends on the signalman. How well and regularly he does this all of us know.

Changes in temperature change the length of the wires and a signal that may work well at one temperature may not work at another. A wire 2,000 ft. long expands or contracts 1.8 ins. for each change of 10° in temperature and as the stroke of the wire at the lever is ordinarily 11 ins., a change of 10° makes an appreciable difference in the movement of the signal and the lever must be pulled with sufficient force to overcome this.

Under certain conditions that occur during freezing weather the wires can not be kept free to move in the pulleys and the signalman has to be depended on to know that the signal is working properly and to fasten it in the normal position if it does not. Boxing does not protect ice from forming and clogging the wires as the boxes can not be made tight enough to keep water and ice out. Oil pipes are not entirely satisfactory, as there is sufficient friction in the pipe, the stuffing box and in cold weather in the oil to hold the wires and keep the signal from going to the normal position in case the back wire should break.

To overcome the probable giving of a wrong indication when a wire breaks, we are using on the C., M. & St. P. Ry. a disengaging lever which up to the present time has successfully released the signal each time the connection has broken. This lever, Fig. 1, must be made of a certain exact dimension or else it will catch and not release as it should do. It is the outcome of many trials and almost as many failures.

To overcome the effect of change in temperature on the length of the wires and also to do away to a large extent with the personal element in the working of the lever, we are using a compensator, Fig. 2, which is nothing more than a crank having a chain sheave on a short arm and two 100-lb. weights on the long arm and the whole fastened by a bearing to the bottom of the signal pole. The arms are in the proportion of 4 to 1 and with the weights put at the end of the long arm, a strain of about 700 lbs. is put on the two wires. With this device no adjusting screws are used as any difference in the length of the two wires results in an increased strain being put on the shorter wire and the stroke of the signal is shortened.

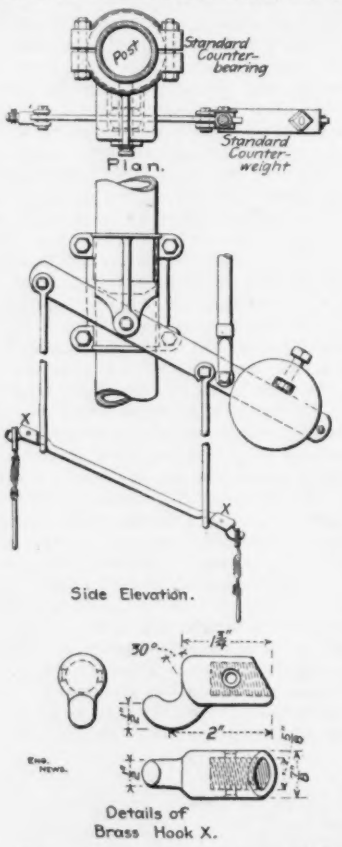


Fig. 1. Disengaging Lever to Release Signal When Wire Connection Breaks; C., M. & St. P. Ry.

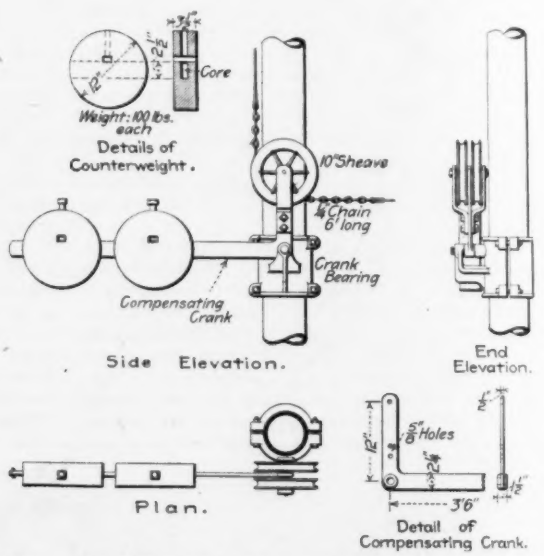


Fig. 2. Signal Wire Compensator; C., M. & St. P. Ry.

Great care must be taken to properly adjust the wires when they are connected up and after that no further adjusting is necessary. Both wires must be given the same stroke at the lever as any increased travel of the back-pull wire allows the weight to drop when the signal is cleared and the weight must be raised again when the lever is put normal.

If the weight compensator is used, the disengaging lever must be used also as without this the breaking of a wire will put a strain of 700 lbs. on the other wire and the signal would be pulled to clear unless it were the down-pull wire that had broken. The disengaging lever must be made to disengage both ways as it will not do to have a 700-lb. pull put on the lever when a man is working it.

In puiting in the connections to a signal, it is very necessary to run the wires so that the least number of turns will be used. Each turn adds considerably to the work to be done and unless the turns are near to the lever, the increased load causes the wire to stretch and the stroke at the signal is so much reduced that it is hard to make the signals go to the proper position. With three turns in the connections and a wire 1,700 ft. long, there will be sufficient stroke at the signal to work it without much difficulty. A large number are in use with four or five turns that work very well but with more turns than this, considerable difficulty is experienced.

When the distant signals are pipe connected, the signal may be depended upon to give a correct indication under most conditions. There is much less spring in pipe than there is in wire and the signal will move with the lever irrespective of how the lever is pulled. With two compensators in a line 2,000 ft. long the pull required, while a heavy one, is not more than many levers are loaded with. Although the pull required is a heavy one, it is possible to spring the pipe and put the lever normal with the signal held in the clear position. It will require so much additional force that the signalman will know that something is wrong, but as ice and snow packing around the carriers will make it necessary to exert about the same additional force, the signalman can not be sure from the pulling of the lever whether the signal had been returned to the normal position or not.

Repeaters working in connection with the distant signal to show if the signal had moved to correspond with the position of the lever, are an additional safeguard and if kept up and observed will give notice to the signalman that the signal is not working properly and he must take the necessary steps to make the indication given a safe one. No doubt repeaters would be more generally used than at present were it not for the expense of installation and maintenance and the fact that the signalman has to be depended on to watch the repeater and see that the proper indication has been received each time the lever is worked. Where the repeater has worked without failure for months and possibly a year or two the men get out of the habit of looking at it and the possibilities are they would not observe it when a failure of the signal did occur. In the last two years two cases have come under my observation when the distant signal had caught at clear and trains were derailed in consequence, although the signalman could see by the back light that the signal had not returned to the normal position and the engineers could see that the home signal was against them, the track being straight and the nights clear.

If our appliances are going to fail so easily and if the men working in the towers are not going to detect failures and take the necessary precautions, is it not better to put in as few of these signals as it is practicable to get along with? Will it not be better to use signals operated by power where the personal element is reduced as much as possible and where the reliability of the apparatus has been amply proved? Is it not the best possible arrangement to make use of a power operated distant signal and put the signal far enough from the home signal to allow a train to pass the distant signal at speed and have the track room enough in which to stop before reaching the home signal? Will it not be the safest arrangement to do away with the distant signal wherever the speed of trains is reduced to 20 miles per hour and the approach to the home signal is reasonably good?

As the cost of any proposed construction has to be considered, it will be of interest to give here a few figures showing cost of the different arrangements which are now in use:

The disengaging lever with the two links in which it hangs, and the pins by which the links are fastened to the balance lever, will cost $1.50.

The weight compensator, consisting of the wrought-iron crank, cast-iron bearing and the two 100-lb. weights, costs $9.

A wire-connected distant signal 2,000 ft. from the lever will cost for labor and material, $140; or, if pipe connected, $440.

Repeaters with two lines of No. 12 B. W. G. bare copper wire run to distant signal 2,000 ft. from tower, wires being run on telegraph poles, will cost $110.

Battery maintenance for four repeaters for one year will cost $36.

Power operated distant signals, provided with two lines of No. 12 B. W. G. bare copper wire run on telegraph poles for 2,000 ft. from tower, all batteries, etc., with installation complete, will cost $310.

Battery maintenance for one year for four power operated signals, each signal being cleared 40 times per day, will cost $40.

AN INTERNATIONAL EXPOSITION at Athens, Greece, which was to have been opened Oct. 15, has been postponed until April 7, 1903, according to a note from Consul F. W. Jackson in a recent Consular Bulletin. The note suggests that the additional time available should induce a large representation of American manufactures. The exposition is intended to cover the fields of Industry, Commerce, Art and Hygiene. Consul Mason says in regard to American exhibits:

It would be difficult to say along what lines special effort should be made, since the Greek market is open to almost anything in the way of manufactures. Certainly farming implements, mechanical instruments and devices of every sort, including typewriters, letter and printing presses (particularly hand and foot-power presses), engines of various types, currant-cleaning machinery, lighting apparatus, lamps, dynamos, and electrical appliances, and a long list of similar goods will find favor with the Greek people.

NOTES FROM THE ENGINEERING SCHOOLS.

TUFTS COLLEGE.—A short course in field geology and determination of rocks has been introduced into the civil engineering course, Mr. Ralph W. Richards being the instructor. The work will comprise one hour lecture and four hours field work each week for half a year.

UNIVERSITY OF ILLINOIS.—The new Chemistry Building has been completed and is partially occupied, although the fixtures have not all been installed. The growth of the Chemical Department is shown by the registration in all chemical courses, which is now 865, as compared with 709 last year. Prof. S. W. Parr and Mr. F. C. Koch have prepared a report on the chemical analyses and heating values of Illinois coals which has been published as a bulletin by the Bureau of Labor Statistics.

CORNELL UNIVERSITY.—Mr. John Vredenburgh Van Pelt has been appointed professor of architecture to fill the vacancy caused by the resignation of Director A. B. Trowbridge. Prof. Van Pelt is a graduate (1895) of the Ecole des Beaux Arts, being the first American to secure the degree of Architecte diplomé par la Gouvernement. Mr. Heinrich Ries has been appointed assistant professor of geology. Mr. Ries is a graduate of Columbia University, having taken his Ph. B. in 1892, his A. M. in 1894, and his Ph. D. in 1896. Since 1895, Mr. Ries has been the clay specialist for the U. S. Geological Survey, and is associate editor of the "Geologisches Centralblatt."

Mr. Herman Diederichs has been appointed assistant professor of experimental engineering. Mr. Diederich has been connected with the engineering department since his graduation from Cornell in 1897. Prof. Elmer James McCaustland has been appointed assistant professor of civil engineering. Prof. McCaustland received his degree in civil engineering from Cornell College, Iowa, in 1892, and has resigned a professorship in the University of Missouri to accept his present position.

Of the 598 graduate civil engineers, only seven have failed to report their present occupation; 30% are presidents, chief engineers, superintendents or managers; while over 40% are assistant chiefs, assistant engineers or professors in universities.

THE FIRE ON THE NEW YORK TOWER OF THE NEW EAST RIVER BRIDGE.

The supporting cables of the New East River Bridge, now under construction at New York city, were seriously threatened by fire on Nov. 11. The fire occurred at the top of the New York tower, some 338 ft. from the ground, and it raged for several hours, the flames being fed by the dry timber work-shanties and combustible stores which were being used there by the contractors, and not being susceptible of successful attack by hose streams, because of their great height above the streets. Fortunately the injury to the bridge structure appears from the preliminary examination of the wreck not to have been great considering the possibilities that existed for serious damage. The contractor, however, will suffer considerable financial loss from destruction of plant and material and the delay in completing his contract.

As most of our readers will recall, the supporting cables of the New East River Bridge are four in number. To construct and adjust them a footbridge was built parallel to and underneath each pair. These footbridges extended from anchorage to anchorage and over the lofty steel towers on the opposite shores of the river. They were carefully and substantially constructed, as described in our issue of Oct. 9, 1902. At the time of the fire the spinning of the cable wires had been completed, and the cable bands carrying the steel suspender cables had been placed. Between these bands work was in progress covering the cables with a waterproof wrapping and steel shell, using the materials and methods of work described by Mr. Wilhelm Hildenbrand, M. Am. Soc. C. E., the engineer for the contractors, in another column of this issue. To carry on this work, which had just been commenced at the New York tower, there were stored at that point a number of barrels of the cable-protecting compound, a barrel of benzine, and miscellaneous combustibles. These were all on a timber platform, which also carried a dry pine work-shanty, and considerable other timber was stored nearby. This timber was well smeared with grease and pitch.

Such, briefly stated, were the conditions at the time of the fire. The story of the fire itself is quite as briefly told. It originated about 4 o'clock p. m., it is claimed, from a carelessly-thrown match which fell among some grease-soaked cotton and ignited it. The workman who threw the match, it is said, ran away frightened without attempting to stamp out the blaze. As it was the hour of quitting work, no other workmen happened to be on the spot, and those nearest were moving along the footbridge some distance away on their journey to the ground. By the time they had discovered the fire and returned to the tower the flames had got beyond the control of the appliances at hand for fighting them. An alarm brought the fire department to the foot of the tower, and then began a desperate struggle by the firemen to carry their hose up the narrow stairway to the fire, 338 ft. above. The hose connections failed again and again under the strain of hoisting it combined with the enormous pressure, and finally when connection was established and the tower platform had been reached the nozzle pressure was so small that the stream thrown was of little effect, except to prevent the spread of the flames. Fully four hours elapsed before the fire was subdued, and by that time the footbridges had burnt off and fallen, and the wooden structure and stored combustibles on the south side of the tower platform had all been consumed. The bridge and the footways as they appeared after the fire was extinguished are shown in the accompanying rough sketch made from near the Brooklyn tower of the Brooklyn Bridge, about a mile downstream, by a member of the staff of Engineering News.

The damage in detail, so far as it could be determined the morning after the fire, is given in the following report written for Engineering News by Mr. Gus. C. Henning, M. Am. Soc. C. E., who personally examined the scene of the fire:

Reaching the bridge at 10 a. m., Nov. 11, I found that the four main cables were hanging clear, while the footbridges directly under them and from which they had been regulated, bound, packed and wrapped, were partially destroyed. The land spans of the footbridges had all fallen down on to the cantilever arms of the shore spans, which are to carry the sidewalks or promenades of the completed bridge. No part of the footbridges fell on the shore span trusses or top laterals, and they did no damage in any way. The ruptured ends of the footbridge ropes had, however, fallen across the top chords of the shore spans so that the fractured ends in every case were lying between the main trusses.

The footbridge carrying ropes had been ruptured on top of the tower, the ends falling either side of it. On the river side these released ropes, three always bundled together to make one cable, had fallen so as to drop on to the floor-beam stirrups intended to carry the permanent superstructure and remained supported on them, and did not fall into the river. The ruptured ends of the ropes did not reach the surface of the river by at least 75 ft. All of the planking, stringers and braces had been stripped off and fallen into the river. These footbridges had fallen to a point about 150 ft. west of the center of the river; beyond that, in an easterly direction, they were still suspended, although the entire structure slid over toward the Brooklyn tower about 100 ft., leaving them intact, however, so that it is still possible to use them

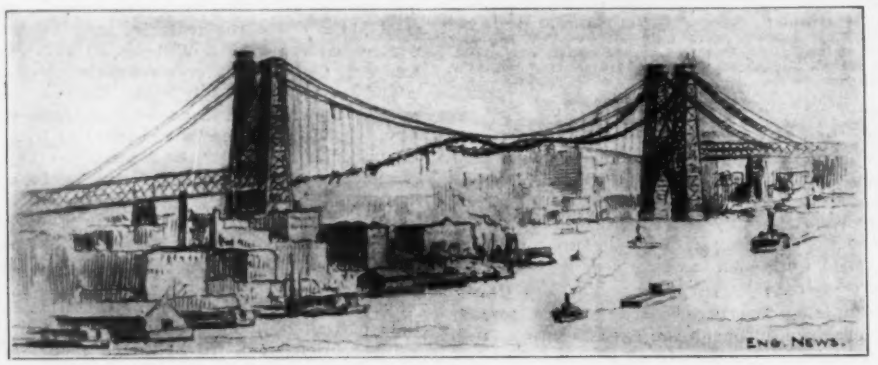
from the Brooklyn anchorage to about 700 ft. beyond the tower over the river. The footbridge storm stays are still suspended, none of them having been broken.

The fire started and spent its force on the south end of the top of the New York tower and worked its way just up to cable No. 2, this being the second cable from the north side of the pier.

In ascending the tower by the stairway it was noticed that no damage of importance had been suffered by even a single strut or girder, the worst injury being a slight bending of the flange of an angle or a strut, and this in but a few cases at unimportant points.

The thickness of the ribs and flanges of these saddles is such that the fire, hot as it was, could not raise the metal to even a low red heat, and they were just hot enough so that the stream of water applied by the firemen raised a very slight rust over night.

The total injury done to the main cable is therefore almost insignificant, and could be entirely made good by cutting out less than 200 wires for a distance of about 5 ft., then splicing in short pieces to replace them. This method is a very easy and perfectly satisfactory one which has been frequently resorted to by Mr. Wilhelm Hildenbrand in a number of other suspension bridges in



SKETCH OF NEW EAST RIVER BRIDGE SHOWING POSITION OF FOOTBRIDGES WRECKED BY FIRE ON NOV. 10, 1902.

(Sketch made from old Brooklyn Bridge.)

It was noticed that burning brands had dropped and set fire to timbers and ropes used at various points, but caused no damage, because of rapid extinction of the blazes. Even the burning of a tool house, which was entirely consumed, did not damage the tower except that two diagonal braces had been somewhat heated; it had stood between the main columns so that the flames did not reach them at all.

On top of the tower all of the woodwork on the south half had been consumed, while heavy charred beams were lying about the saddle on cable No. 3, and the scaffold to the north of this point was also badly charred before the blaze was extinguished by the fire department.

True north runs through the diagonal of the tower and hence the flames traveled diagonally across the tower under the effect of a sharp north wind. The result of this was that the westerly ends of the saddles and the cables resting on them were not even touched by the fire, while the flames merely swept over the easterly half of the two southerly saddles carrying cables Nos. 3 and 4. The fire creeping in a northerly direction against the north wind merely scorched the easterly end for a distance of about 3 ft. and also the cable No. 2, lying on it, for about the same distance. This cable, No. 2, is so little injured that it will not be necessary to make any repairs to it, although the waterproofing in the saddles and on the cable will have to be replaced.

The fire sweeping over the easterly halves of saddles carrying cables Nos. 3 and 4, they were affected in a like manner. After all the heavy mass of waterproofing had been consumed the fire reached the upper layers of the wires of the cables in the saddles for a distance of less than 5 ft. These superficial wires, of which there are about 100 in each cable, show that they had been at a red heat on the upper surface, but in raising them up so as to inspect the underlying layer of wires, no injury to them was apparent, and they were not even covered with rust. This is the strongest evidence of merely superficial effect of the fire on the cable wires. Now, if we assume that as a maximum each of these 100 wires in both cables had lost about 15% of their strength, due to being subjected to a red heat for a short period, this would mean that the strength of each of these two cables composed of 7,700 wires was approximately reduced by the resistance of 15 wires. Such a slight reduction of the total strength of the cables would reduce their factor of safety by less than 0.2%, which is an entirely negligible loss of strength.

There was another point at which cable No. 3 was affected by the fire, viz.: on its northerly side, just where it left the saddle and for a distance of less than 2 ft. The steel jacket had not yet been placed on this cable at this point as had been done in the case of cable No. 4; and therefore the wires in No. 4 were not touched by fire, although the jacket was very slightly bulged by the flames. The wind drove the flames from the center of the tower directly against and under the northerly side of cable No. 3, at this point, and perhaps 40 wires had reached a temperature sufficient to raise a very slight scale. This injury to a few wires in this cable is so slight that it can be neglected entirely.

The easterly ends of the northerly faces of saddles Nos. 3 and 4 showed the effect of the fire, as they were covered with rust, although at no place did they show scale due to a red heat.

which moisture had after many years caused corrosion of the external wires, which made it seem advisable to replace them by new ones.

Nowhere is any injury to the structural work at the top of the towers visible, except that one longitudinal brace running from the south to the north towers is slightly bent by the heat. This strut can, however, be straightened or even replaced, although it is of secondary importance.

Examination of the broken ends of the wires in the footbridge cables reveals the fact that they had been brought to a red heat and were then torn apart by direct tension like in a tension test, with a cup-shaped fracture in every case, only that these ends were gradually tapered down for a length of from 2 to 3 ins. from the fracture, as occurs in red-hot wire when under tension. The galvanizing of the wires of these ropes had been plainly affected by the heat about 3 ft. from the point of rupture, showing the distance over which they had reached a high temperature.

The southerly footbridge nearest the origin of the fire fell first, the adjoining ones giving way one after the other in about 1¼ hours, as the fire gradually reached them successively.

The fire was of sufficient intensity and duration to burn out the chocks which held the saddles on top of the towers in a position about 36 ins. west of their axis for purposes of construction. As soon as these chocks were burnt, beginning with the southerly one first, the saddle was released and it, with its superimposed cable, moved toward the river until equilibrium of tension in the cable had been established. Thus one saddle moved after the other without causing any damage. The amount of motion of these saddles was from 6 to 9 ins.

From the above it will appear that the actual damage to cables, saddles and towers is much less than could ever have been imagined possible, and a few thousand dollars will suffice to make all necessary repairs. The contractors will, however, suffer a damage of from $50,000 to $75,000 due to loss of equipment, tools, material and increased cost of completing their work. The fire will probable cause a delay in the completion of the structure of about two months.

An examination of the wreck was also made by Mr. Gustav Lindenthal, M. Am. Soc. C. E., Commissioner of Bridges, who reported his findings to the Mayor as follows:

The origin of the fire is as yet unknown. From a personal inspection which I made this morning, I find that the flames found nourishment in the timber of the scaffolding and the wooden temporary stairway in the southern half of the tower. In ascending from the bottom of the tower (where the fire started), the flames reached the wooden shed on the top, which temporarily incloses the steel wire cable bearings on the towers. In that shed had been stored the materials used in covering the cables, some of which materials are of an inflammable nature.

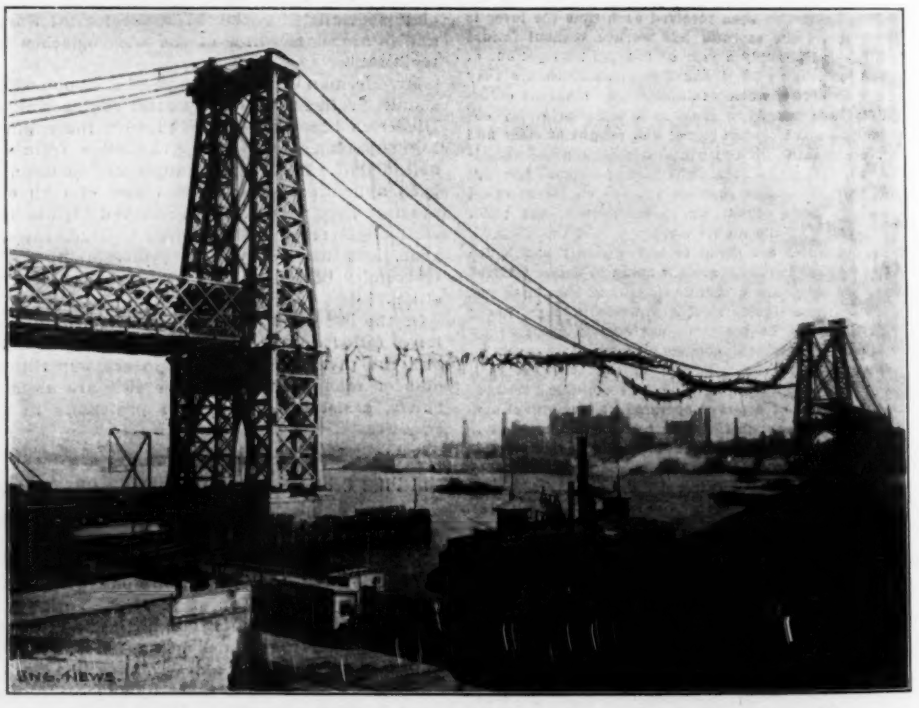
The fire was hottest at the top of the southern half of the tower. It consumed all the timber, and so softened the wire ropes of the footbridge that they tore apart, and the footbridge fell. That part of the footbridge directly over the river was prevented from dropping into the river by catching on the suspender rods fastened to the main cables.

Three of the main cables have been damaged by the fire at points near their saddles—to what extent has not yet been ascertained—but it will be less than at first supposed. It will be necessary to cut out the damaged wires—probably several hundred of them—and replace the same with sound wires. This work may delay the completion of the structure not to exceed sixty days.

The bracing between the towers has been bent and warped in several places, and it will have to be straightened. A minute inspection of the damage sustained is now being made by engineers of this department. A preliminary estimate of the damage does not exceed $50,000.

It is almost miraculous that no lives were lost. Had the fire occurred one-half hour sooner, when over one hundred workmen were on the footbridges, working on the main cable, great loss of life would have been almost unavoidable.

None of the damage will fall upon the city, which is amply protected in its contract for the work. The principal loss was sustained by the John A. Roebling Sons Co., which company has the contract for the steel wire cables. The fire was of an unusual nature, and probably the first of its kind in the history of metal bridge construction.



VIEW OF NEW EAST RIVER BRIDGE, FROM A PHOTOGRAPH TAKEN NOV. 11.

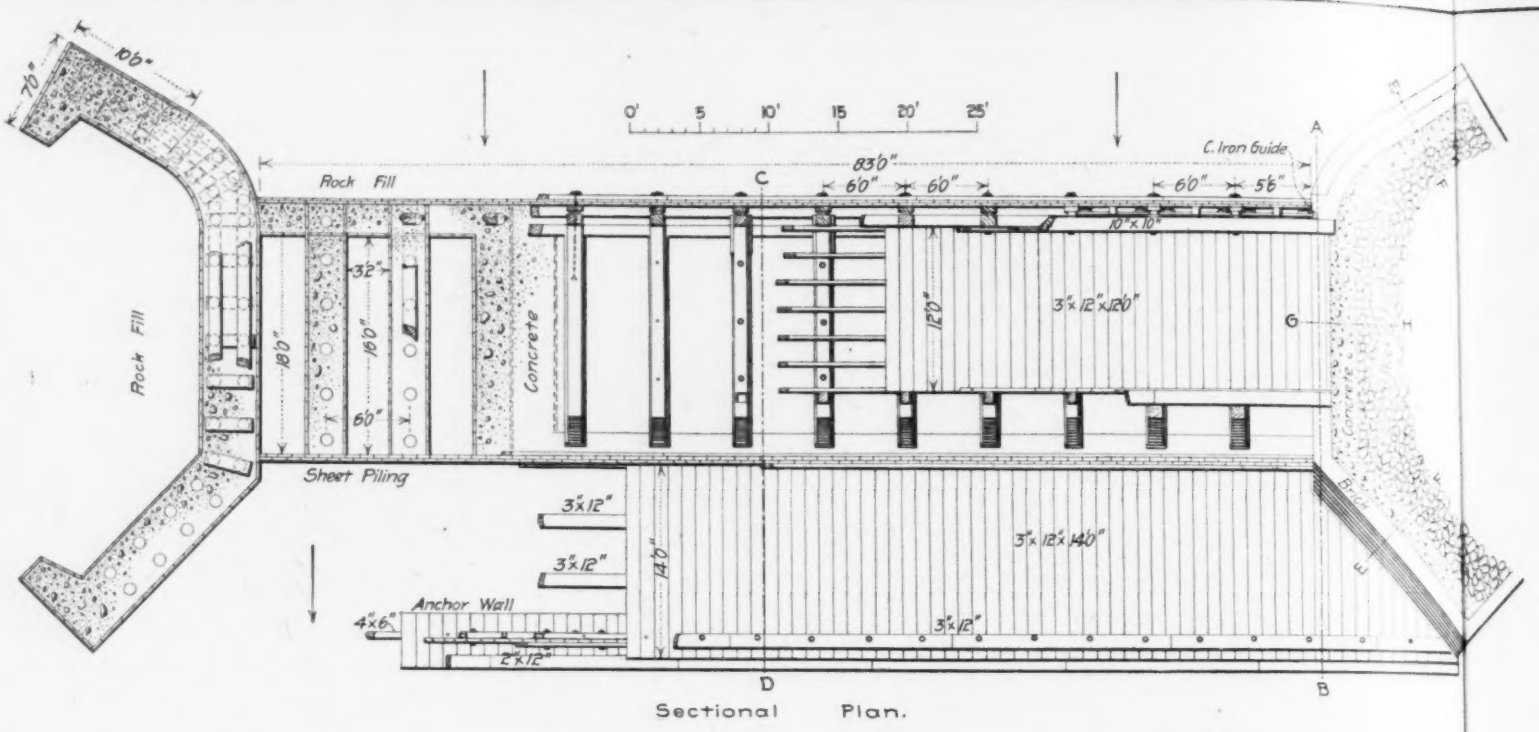


FIG. 3. PLAN AND SECTIONS OF HEAD-GATE, FT. LYON CANAL.

STRUCTURES ON THE IRRIGATION SYSTEM OF THE ARKANSAS VAL

Thos. Berry, Chief En

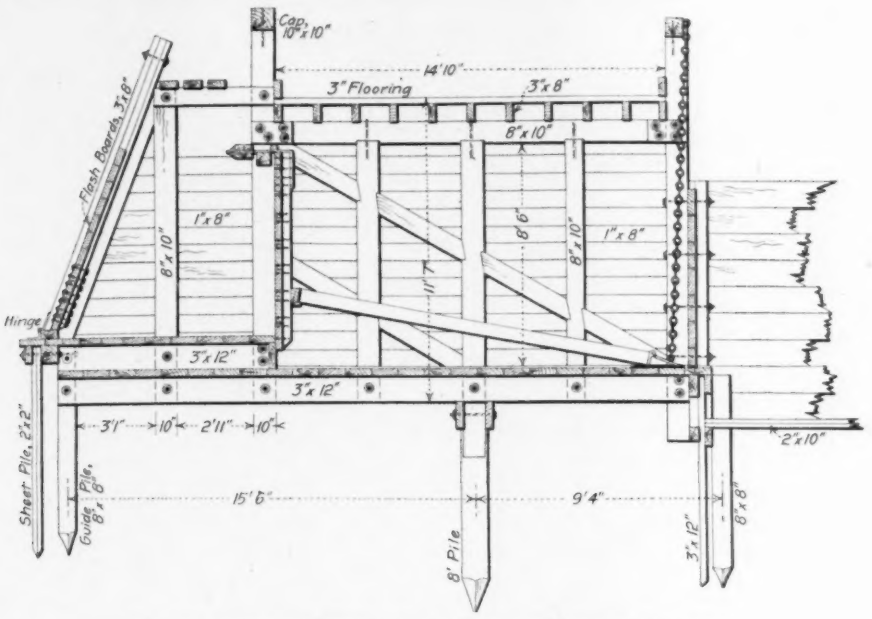


FIG. 5. CROSS-SECTION OF GAGEBY ARROYO WASTEWAY, FT. LYON CANAL.

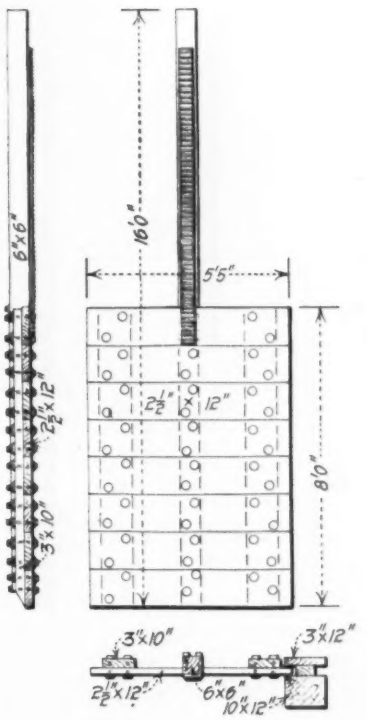
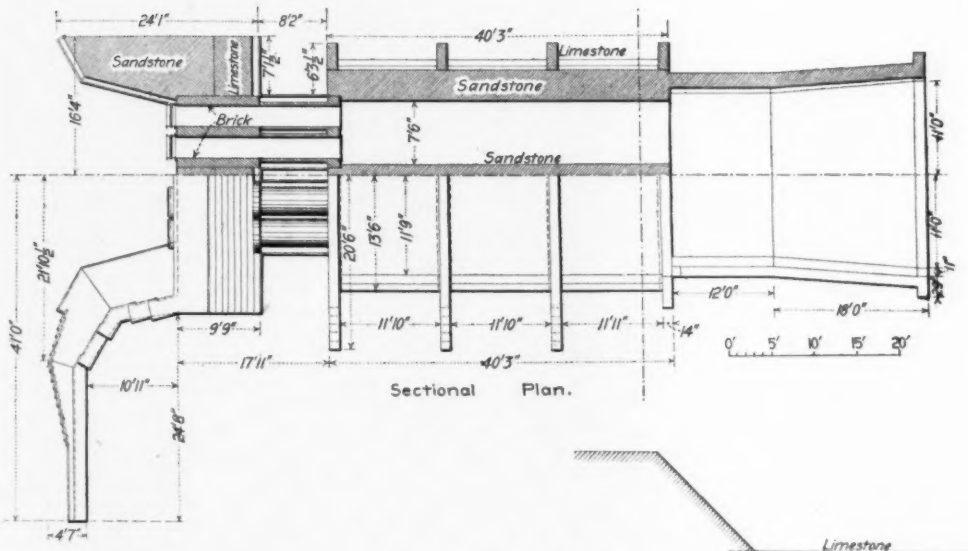
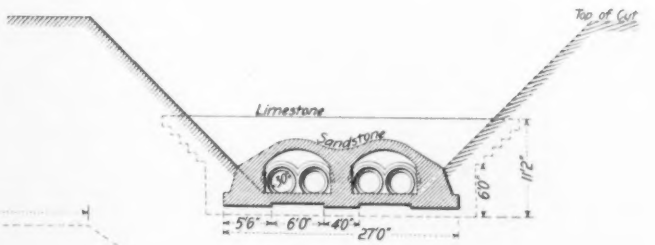


FIG. 4. DETAIL OF ONE OF THE GATES IN FT. LYON CANAL HEAD-GATE.





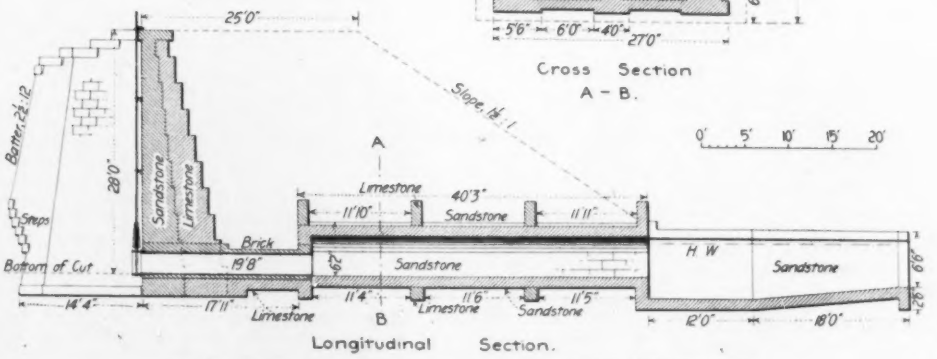


FIG. 9. PLAN AND SECTIONS OF NEE NOSHE HEAD-GATE, COMANCHE CANAL.

ARKANSAS VALLEY SUGAR BEET AND IRRIGATED LAND CO., COLO.

Berry, Chief Engineer.